UNITED STATES DEPARTMENT OF AGRICULTURE

# FOREST SERVICE



THE MADISON CONFERENCE

PROCEEDINGS OF THE FOREST EXPERIMENT STATION CONFERENCE

U.S. FOREST PRODUCTS LABORATORY

MADISON, WISCONSIN

March 10-22, 1924

GOVERNMENT PRINTING OFFICE 8—6150

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## MADISON, WISCONSIN

March 10-22, 1924

E. H. Clapp, Chairman

"The Madison Conference," as it is now called, was a meeting primarily of the research men in the Forest Service. This meeting was held at the Forest Products Laboratory from March 10-22, 1924. This is the second time that the men in the Forest Experiment Stations have had an opportunity of getting together; the other being in 1917, when the meeting was held in Washington. This meeting was the first time that members of the forest products organization and forest experiment stations organizations have had the chance to get together.

The meeting was called primarily for three objects:

(1) To get together and discuss the various problems that resulted from the completion of the field work in the various silvicultural requirements reports, and to coordinate the recommendations.

(2) To iron out the difficulties arising in connection with growth and yield investigations.

(3) To coordinate the work of the research men in forest fire investigations.

Representatives of each of the Forest Experiment Stations were in attendance in addition to men in Forest Management from the District organizations where the requirements work has been carried on. For the section of the meeting devoted to the discussion of fire, men in the administrative organization who had been working upon these topics were in attendance.

The meeting has done much to unite the entire research force into a more homogeneous organization, and to bring about a closer coordination of the work of the men at the different stations which are more or less isolated from one another. Various committees reported, and in these committee reports are summarized perhaps the chief definite accomplishments of the meeting.

The major decisions arrived at in the course of this Conference were as follows:

(1) The publication of a complete set of papers on the silvicultural requirements for our American forest types within the next year or two.

(2) The coordination of the silvicultural requirements for certain tree species which are found in more than one region, as for example, the western yellow pine.

(3) The publication of the results so far attained by the investigative force in the prediction of fire weather warnings.

(4) Desirability of a publication in each of the National Forest Districts of a bulletin summarizing the analysis of fire statistics to show the progress of the Service as an organization.

(5) The maintenance of current analysis of all fire statistics as far as is possible within the Forest Service organization, and the stimulation of the state forestry organization to a similar analysis of their problems along similar lines.

(6) The realization of the need for a method of application of normal yield tables. (This problem appears to be one of the biggest confronting research in growth studies.)

(7) The necessity for a decision as to the methods to be employed in growth and yield studies, and the need for a manual covering the same.

In addition to the tangible results above mentioned there are the intangible results brought about by the contact with the men working in the field on studies involving the growth of timber with those who are interested in the forest products.

The field men were very greatly interested in the work of the Laboratory and a trip was arranged for them through the Laboratory in which they were shown the work of the various sections. The time for this was all too short. As an evidence of the appreciation of the field men for the courtesies extended them; by the dinners arranged for them; through the help and assistance given them by the Laboratory force; and through the privileges extended to them at various clubs in the city and in the Laboratory buildings, a loving cup was presented the Laboratory to be used as a prize for excellence in sports as might be decided upon by the Forest Products Club.

In addition to the courtesies shown the men by the Laboratory, Dr. Richard T. Ely of the Land Economic Institute extended to the men the courtesies of his organization through a trip to his laboratory, and through a dinner to the visiting members.

The following list includes the members of the field force who were in attendance, exclusive of the members of the Forest Products Laboratory, a number of whom attended a part, or all, of the meetings. The members of the Laboratory in attendance are not given except as they participated in the discussions.

## ATTENDANCE

### Washington

| | |
|---|---|
| Forester - | W. B. Greeley |
| Research - | E. H. Clapp<br>Ward Shepard<br>C. F. Hunn<br>E. N. Munns<br>R. M. Brown |
| Grazing - | W. R. Chapline |
| Operation - | Evan W. Kelley |
| Forest Management - | E. E. Carter<br>C. R. Tillotson |
| Publications - | M. C. Merrill |

### Forest Experiment Stations

| | |
|---|---|
| Appalachian - | E. H. Frothingham<br>E. F. McCarthy<br>C. F. Korstian |
| Southwestern - | G. A. Pearson<br>Herman Krauch |
| Fremont - | C. G. Bates |
| Lake States - | Raphael Zon<br>Joseph Kittredge, Jr.<br>J. A. Mitchell |
| Northeastern - | S. T. Dana<br>C. E. Behre |
| Priest River | R. H. Weidman<br>H. T. Gisborne |
| Southern - | R. D. Forbes<br>W. R. B. Hine |
| Wind River - | Julius V. Hofmann |

## Districts

| | |
|---|---|
| District 1 - | Howard R. Flint<br>Elers Koch |
| District 2 - | John McLaren<br>Crosby A. Hoar<br>M. W. Thompson |
| District 3 - | R. E. Marsh |
| District 4 - | C. B. Morse |
| District 5 - | E. I. Kotok<br>S. B. Show<br>Duncan Dunning |
| District 6 - | W. B. Osborne, Jr.<br>R. H. Chapler<br>Thornton T. Munger |

In addition to the above members of the Forest Service were the following:

| | |
|---|---|
| U. S. Weather Bureau - | H.J.Cox, Chicago, Ill. |
| Minnesota - | T. S. Hansen, Cloquet Experiment Station |
| | G. M. Conzet, State Forester |

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## INTRODUCTION

## I. FOREST FIRE INVESTIGATIONS

## II. GROWTH AND YIELD INVESTIGATIONS

## IV. DIGEST OF REPORTS ON PUBLIC REQUIREMENTS, DESIRABLE PRACTICE, AND DEVASTATED LANDS FOR THE PRINCIPAL FOREST REGIONS OF THE UNITED STATES

# PART I. FOREST FIRE INVESTIGATIONS

## I. FOREST FIRE INVESTIGATIONS

1. A concise statement of the outstanding characteristics of the fire problem of the important forest regions, covering such points as character of the cover, characteristics of the fires, seasonal variations, number and distribution of the fires, etc.; particular reference to those phases which require investigations; enough justification or explanation to make the points conclusive. This discussion should furnish a background for all that follows.

### Fire Problems in the Northern Rocky Mountains

Howard R. Flint

The Northern Rocky Mountain District is an important forest region in which forest fires are probably of more frequent occurrence and of more totally destructive character than elsewhere in the United States.

Protection successful during all but the exceptional years. An insurable loss during the ordinary years.

In 16 years of record 18,820 fires on D-1 National Forests have burned over 4,400,000 acres, killing $10\frac{1}{2}$ billion feet of timber worth 27 million dollars. Suppression has cost $5\frac{1}{2}$ million dollars.

Of the loss in acres, 89 per cent occurred in two seasons, 1910 and 1919. Recognition of such extreme seasons, in advance of their approach is of supreme importance.

The number of fires per year varies from 373 to 2258.

Lightning is the greatest single cause of fires. It causes from 67 to 1281 fires per year.

It has caused about 35 per cent of our fires in past 16 years; railroads are second, but such fires are easily handled. Lightning fires come bunched - 200-300 in one day. Too big a load for the organization.

Moisture content of the fuels is an important factor influencing the number of fires and is the most important of all factors in determining the extent and intensity of fires.

Extreme dryness of the fuels is caused by unusual and extreme climatic conditions which are also often accompanied by the occurrence of much lightning. Advance knowledge of the approach of extreme dry conditions of fuels would be of inestimable value.

The greatest probable assistance which research can render to the solution of the general fire problem in D-1 is found in three specific problems as follows:

1. The development of a means of applying 36-hour or longer weather forecasts to the forecasting of the degree of inflammability of the important fuels.

2. The development or discovery of a means or method of forecasting, in time and place, the occurrence of lightning storms.

3. The discovery or development of a dependable method of determining two weeks or more in advance the approach of abnormal seasons.

Discussion

Greeley - Will 24 hours warning enable you to cope with widespread danger?

Flint - Yes, if dependable. The force can be increased in 24 hours. Would add new men, not move existing men. The ordinary forest officer is not able to interpret weather forecasts with sufficient accuracy.

Fire Problems in the Pacific Northwest
Wm. B. Osborne, Jr.

Principal types from Protection point of view

1. Coast Type

Narrow strip along Pacific Coast, and west slopes Olympic Mountains and Coast Ranges.

Dense mixed stands Spruce, Hemlock, D. Fir and Cedar.

Dense underbrush in timber and rank growth in openings.

No lightning fires.

Very heavy duff.

Heavy tree moss.

Precipitation 70-90" rainy season; normal for July, .7 to 1.2; August, .6-1.2; September, 3 inches.

Hazard normally low, occasionally extremely high. Strip has suffered from some of the worst fires of the whole Northwest.

2. Douglas fir type

Located between summit of Cascades and Coast belt and from British Columbia to within short distance of California line.

Dense even-aged stands Douglas fir, with western hemlock and cedar as associates; Douglas fir 70-80%.

Very heavy duff, tree moss coming in above 2500-ft. elevation.

Annual precipitation, 35-60"; normal June, 1.5-3; July, .4-1.4; Aug., .6-1.7; Sept., 1.7-4.2.

3. Yellow pine type

Located along foothills of eastern Oregon and Washington; i.e., around Blue Mountains and east side of Cascades; crosses to west side of Cascades on Crater and Siskiyou Forests north of the California line.

Stands average about 15 M.B.M.; broken by brush patches; considerable young growth under stands.

Little to no duff.

Annual precipitation 12 to 20"; normal June, 1-1.5; July, .3-.4; Aug., .3-.5; Sept., .6-.8.

4. Upper slope types

Higher elevations of Blue Mountains and summit of Cascades to yellow pine belt.

Fir, larch, and lodgepole type, Blue Mountains; Douglas fir, white fir, white pine, and mountain hemlocks along Cascades.

Light to moderate duff condition.

Moderate to heavy moss both regions.

Annual precipitation, 20-30 for fir-larch, and 30-80 for Cascade group.

Number and distribution of fires

National Forests only average last 7 years 1350 about evenly distributed between east and west side of Cascades; 35% caused by lightning. Outside National Forests only 10% of total caused by lightning.

Characteristics of our fires are

1. Marked fluctuations in intensity at different periods of the day in all types.

2. Tendency in many cases to smoulder for days in heavy duff with no appreciable spread.

3. Tendency to develop into crown fires.

4. Great persistency in heavy duff types.

5. High inflammability, rapid spread, easy control in yellow pine type.

The outstanding problem is creation of slash. It represents a constant hazard to timber until disposed of.

Osborne stated that the normal fire season lasted from 3 to 4 months on lightning fires and was evenly distributed except for the fog belt. The major per cent of loss is taken in relatively a few days, usually 1 to 3. The chief risk results from the large amount of slash, about 200,000 acres being created each year, and from the fact that old burns are more inflammable than green timber. The area of the hazard in the "moss type" amounts to 12,000,000 acres.

## Fire Problems in California
E. I. Kotok

1. Four distinct regions:
   - (a) Redwood region
   - (b) California pine region
   - (c) Watershed forests, southern California
   - (d) Woodland and chaparral adjacent to pine region

2. Redwood region

   - (a) Area, 1,630,000 acres.
   - (b) Dense forest cover in fog belt and partially stocked cut-over land invaded with brush.
   - (c) Virgin forest; hazard generally low or absent; occasionally extreme, developing into crown fires.
     Cut-over areas, constant hazard, fairly high.

(d) Causes of fires: almost exclusively man-caused and preventable.
(e) Practically nothing known about damage. Great importance of climatic control of fires.

3. Pine region

(a) Area, approximately 15,000,000 acres.
(b) Forests, understocked, full of underbrush and checkered with brush fields. Highly inflammable.
(c) About 1,200 fires annually - 1/3 lightning. Frequently occurring in peaks, with as many as 325 fires in a day. Extreme seasons of 190 days with constant danger, occasionally excessive.
(d) Annual acreage burned about 135,000. Occasionally individual fires reaching 25,000 acres; seldom crown fires. Damage at least 2/3 of total spent for protection and suppression.
(e) Least damage in virgin forests, reduction of hazard in other types essential. General undervaluation of damage.

4. Watershed Forests, California

(a) Area, between 5 and 6 million acres.
(b) Enormous unbroken areas excessively inflammable brush fields.
(c) Average about 250 fires per year, of which over 35% are C's.
(d) Burned area about 2.2% of total per year. 50,000-acre fires not unusual; all develop into crown fires.
(e) Season 8 months, occasionally 12 months.
(f) Important consideration:
    1. Relation of cover and water resources and erosion.
    2. Reduction of hazard.
    3. Weather forecasts.
(g) Possibility of changing present brush cover to forests.

5. Chaparral and Woodland

(a) Area, 10,000,000 acres.
(b) Dense, highly inflammable brush land with comparatively little true forest.
(c) About 800 fires per year.
(d) Area burned, about 300,000 acres.
(e) Season about seven months, with extreme critical points corresponding to other regions.
(f) No land policy; used chiefly for grazing where fires are encouraged; population disregards timber or watershed value.
(g) Fires in this belt a constant threat to pine region proper.

Discussion

Clapp - How does this agree with the troubles in California?

Kotok - agrees with Osborne that there are practically no lightning fires in the fog belt. The extension of the brush and woodland types into the pine is the result of fires.

The outstanding problems of the California district are practically the same as in Districts 1 and 6.

## Fire Problems in the Southwest
R. E. Marsh

1. General conditions

   a. Cover types. About one-third of district is sawtimber type, of which over 80% is W. Y. P. and the remainder is divided about equally between Douglas fir type and spruce type.

   b. Season. Commences in May, culminates in latter part of June and early July, when the summer rains commence. This dry spring season is characteristic of the Southwest. Some years a secondary season late September to early November.

   c. There are three distinct regions with respect to fire:

      (1) Colorado Plateau
      (2) Northern New Mexico
      (3) Arizona Brush

2. Colorado Plateau. Most serious problem of all. Largely W.Y.P.

   a. Extremely dry spring season characterized by high winds.
   b. High lightning risk. Lightning comes in advance of rains.
   c. Partly heavy bunch grass.
   d. Much cut-over land.
   e. Get fires up to 3000 acres. One of the objectives is further reduction in fires, especially on cut-over areas.

3. Northern N. Mex. Large areas not only W.Y.P., but Douglas fir and spruce types.

   a. Lower lightning risk.
   b. Less distinct dry spring.
   c. Large areas of Douglas fir and spruce devastated by old burns, as to which there are several theories. Further study is needed as to the practicability of further cheapening protection costs by the use of Pearson's rainfall studies. This will involve checking the theories as to the large burned areas.

4. Arizona brush

   a. Hazard greatly lowered by overgrazing in last 40 years, but this has resulted in tremendous watershed damage.

b. Overgrazing has reduced grass competition and fire damage and thus promoted establishment of W.Y.P. and juniper reproduction over large areas.

c. Light grazing appears to mean more brush and grass, therefore greater fire hazard but less watershed damage.

d. The foregoing may indicate that the brush is a temporary type. Study is needed to determine whether this theory of type succession and causation is correct and whether watershed protection or fire hazard reduction should have priority.

5. Finally as a needed investigation is recommended a study of climatic trends and cycles. At present our research and administration is premised on the following assumptions:

a. An absence of definite climatic trends, and

b. While drouth cycles exist they are not predictable in the sense of applying them to administration.

Chapline asked if heavy grazing would help to keep down fires.

Marsh did not specifically recommend heavy grazing for this purpose, but advised rather the reduction of grazing.

Chapline agreed that overgrazing should be reduced.

## Fire Problems in the Southern Pine Region

R. D. Forbes

1. Extent and frequency. Larger percentage of region burned annually than of any other region in United States. Longleaf lands more widely burned than shortleaf lands.

2. Chief causes: incendiarism by stockmen probably as high as 75%; hunters and campers; railroads and tramroads; turpentine operators; miscellaneous.

3. Character of hazard. Slash created on 3 million acres annually. In mature timber main hazard is leaf litter, normally not over 4 inches deep, owing to oxidation and decay. In open stands and cut-over land main hazard is luxuriant growth of grasses. Palmetto, gallberry, and a few other species of underbrush bad hazard on some soil types.

4. Fire seasons. Normally fall and winter, but extended drought may permit fires at any time.

5. Damage. Damage from any one firehard to segregate from cumulative effect of earlier fires.

There is great indifference to fires in the South.

Longleaf pine areas burn more frequently than shortleaf.

10,000-acre fires are common.

Stockmen have been accustomed to burning the woods in the belief that it improved grazing conditions.

We need proof that fire does not benefit the range.

There is almost no authentic instance of lightning starting fires in this region.

Crown fires do not occur except in young stands.

There are two fire seasons - spring and fall; severe droughts may occur all through the year.

Fire damage in this region does not result in total destruction; most of the damage is to reproduction.

The region has no present fire prevention objective.

A low value is attached to analysis of statistics, and to forecasts because organizations are in a formative stage. Not ready for such work.

## Fire Problems in Colorado, Wyoming, South Dakota and the Lake States

John McLaren

With a net acreage of 20,124,630 in the National Forests in District 2, there has been burned during the past ten years 181,460 acres, or 9/10ths of one per cent of the total. About 2/5ths of this acreage is timbered land, the balance open or brush not supporting tree growth. Loss in values for timber, reproduction and forage totals $265,706. Cost of suppression was $224,609.

Of a total of 3713 fires during the period, the lowest number of fires recorded for any one year is 193 for the year 1923, the highest 493 in 1916. Of the total number of fires occurring 583, or 16% originated outside the Forest boundaries and 465 of these were stopped before they crossed inside.

### Fire Season

With the Forests scattered through six States, there is a wide variance in the opening dates and length of the fire season, and fires may reasonably be expected in any month of the year except December, January and February. In the Lake States and in the western part of the District, we usually have both a spring and fall season, the months of July and August generally giving little trouble.

The spring season in the west is usually passed without much anxiety, and though fewer fires occur in the fall this is the period of greatest hazard. Spring fires are generally confined to south slopes and open grass areas while snow yet remains in the timber. In the fall after the grass is cured and foliage is dropping from the aspen, oak and various kinds of brush, fires burn with great rapidity and almost invariably become crown fires unless they are caught very quickly after inception.

Hazard

The yellow pine type in South Dakota and the lodgepole in southern Wyoming and northern Colorado constitute our greatest hazard in the west. The timber in the Black Hills region was bug killed about twenty years ago but is restocked and fire takes to the crowns in incredibly short time. In the lodgepole region mentioned, fires have been known to crown in less than thirty minutes after their inception.

Since sixty to seventy per cent of the fires are reached within two hours after discovery, practically no loss is encountered in the Engelmann spruce type.

Fires in the Lake States now constitute our greatest problem. Transition into the fire season sometimes occurs almost over night, and at least it is no exaggeration to say that it easily occurs over the week end. Litter on the ground, consisting largely of dead grass and leaves, is highly inflammable. I don't like to quote too many figures but possibly this point may best be illustrated by the following:

During 1923 nineteen fires occurred in Michigan and all of them were discovered within fifteen minutes; 79% was reached in an hour or less, and on none did over two hours elapse before the arrival of suppression forces; yet 63% of the total number was of Class C size.

Causes

Covering a period of ten years, railroads have been responsible for 30% of the fires, though in the past year or two this has been cut to less than half, and the damage from this class of fires has been almost negligible for the past two or three years.

Lightning has been responsible for 20% of the fires, and these occur over widely scattered regions. In few cases have they resulted in bad fires, and then almost without exception because of human failure somewhere along the line.

Smokers and campers are now the chief sources of trouble for fires which originate inside the boundaries, the former particularly because of the greater uncertainty as to what route of travel they may take.

Need for Decreasing Human Error

Referring to the graphs (on the wall), it is found that for every high peak in acreage burned or cost plus damage, analysis discloses human faults, which, properly guarded against, would have made different history. Not only is the time short but you will not be interested in a lengthy analysis. To illustrate my point, note the graph indicating cost plus damage for the ten-year period 1914-1923, inclusive.

In 1915 cost plus damage reached $42,000 for the western part of the District. One fire involved $27,000 of this amount because a sawdust pile had been suffered to burn at an abandoned site with one man left to watch it.

In 1916 the total went a little over $70,000. Considerably over half of the deficit was caused by one Wyoming fire where a certain individual had consistently refused to discontinue burning on private land.

In 1919 the high peak of $150,000 was reached, and 80% of this is charged to one Forest, most of it covered by two fires. This was a year of extreme drouth which extended throughout District 1 and into northern Wyoming. A Supervisor recently transferred to the Forest in question had come from a Forest which always had been comparatively free from fire. A lightning fire occurred and there was a long lapse of time in discovery, though it started within a mile and a half of a lookout point. Inquiry developed that it had not been manned because the B-NF did not provide for a lookout at this period and the policy of putting on emergency guards had been overlooked. Had there been a competent observer on the job, action would probably have resulted in holding the fire to less than a quarter of an acre. An observer was secured, but he proved incompetent when a little later in the season lightning set a fire within three-fourths of a mile of the lookout. The observer became panicky, lost his head and, without taking his personal belongings, left that part of the country without even reporting the fire. Before it was reached a whirlwind picked it up and scattered it like a salt shaker for about two and one-half miles.

For the Lake States, note that in 1917 cost and damage is indicated at about $18,000; 75% of this occurred on one fire and, in all probability, unnecessarily because of not having a sufficiently intensive detection system. The lookout picked up the smoke and promptly reported it, but misjudged the distance some three-fourths of a mile, and that is a long way in a lake and swamp country. It blew up before it was located by men sent to suppress it.

In 1918 there is a total cost and damage of about $24,000. Only outstandingly efficient work in Minnesota held it at this figure, for that was the year the State was dotted with hundreds of small fires, when practically no effort was made to control any of them, and the stage was set for weeks for the awful holocaust which occurred on October 12 of that year. When the crisis came we were more or less side swiped.

In 1923 the high water mark was reached with a total of $41,000. In general the situation was well handled except on one fire where failure at several points accounts for about $25,000 of the total. The balance was mostly cost of holding off outside fires, but right action and continuous effort would likely have saved us the $25,000, for the fire should have been confined to private holdings without expense to us.

Taking advantage of lessons learned through experience and ironing out human failures mentioned, make it evident that the "peaks" would be pretty largely eliminated over a period of years including both favorable and unfavorable from a seasonal standpoint.

Location of Origin

Fires originating outside the boundaries in the western part of the District rarely cause us much expense and almost always are extinguished before they are communicated to National Forest lands. On the other hand, it is the fires originating outside the boundaries that give us most concern in the Lake States. Settlers, particularly in Minnesota, have been careless and callous for generations. Until recently railroads did not properly provide against fire nor undertake their responsibility for fire control. Lumbermen used to be entirely indifferent to fire except as merchantable timber, camps or plants were threatened, and even today there are too few who use judgment or care with fire, particularly as it relates to slash burning.

Research Problems

1. Plan to continue evaporimeter experiments which have been carried on for a year. Deductions may prove valuable in forecasting fire weather and supplement relative humidity studies in District 6.

2. Both evaporimeter and relative humidity studies desirable in Minnesota to help further educational work and provide definite data for lumbermen and settlers who now burn indiscriminately.

3. The remark has frequently been made that there must be something in the air in Colorado and Wyoming which prevents fires from burning. I should like to see research investigations started which will give comparative data for various parts of the country along this line.

Discussion

Hoar - There is no cooperation or appreciation by the public in fire protection and prevention in Minnesota; that the entire situation in lower Michigan had been aggravated by past fires and consequent excessive surface dryness. In the upper Michigan hardwood region, timber owners are indifferent to prevention of fires. Fifteen to 16 million acres require protection. The heavy draining of forest bogs has resulted in surface drying and a serious fire hazard. In spite of the

snowstorms which occurred late this spring, 300 forest fires are burning now and probably will continue to burn during the coming fire season. He estimated that one-half to a million acres were burned each year.

## Fire Problems in the Inter-Mountain Region

C. B. Morse

### General Statement

District 4 divided into 2 parts for fire discussion.

1. High fire hazard - Southern Idaho and Western Wyoming.

2. Low " " - Utah, Nevada, and Northern Arizona.

Southern Idaho fire problem directly comparable to southern part of western portion D-1 and eastern Oregon and that of western Wyoming to eastern D-1. The problem in Utah and northern Arizona is directly comparable to the Colorado plateau region of D-3 and D-2.

Crown fires are not common in the southern part of the District on account of summer rains in July and August, and heavy grazing. In Idaho, however, fires crown very rapidly. The yellow pine type is broken by stands of Douglas fir, spruce, and white fir occurring on north slopes.

### Summary - Fire Statistics - D-4 - 1908 to 1923

| | Total 16 Yrs. | Average | 1923 Only |
|---|---|---|---|
| Number of fires | 5,235 | 328 | 260 |
| Suppression Costs | $534,953 | $33,367 | $3,822 |
| Acres Burned | 606,960 | 37,933 | 682 |
| Damage to Forests | $1,308,475 | $81,779 | $1,581 |

| | Average Precipitation 5 Months, June-October | Average Length Fire Season 1915-1923 |
|---|---|---|
| Fire Forest Group | 4.23 in. | 86 days |
| Non-fire Forest Group | 5.52 " | 108 days |

1908 to 1923

3890 fires on 8 forests of the Idaho-Wyoming group out of 5235 for the 26 forests in D-4

1908-1920

Causes: Lightning nearly 50% - Campers nearly 33%.

What D-4 wants of Research:

1. A scientific index of actual conditions on the ground which will tell us when fire conditions really are bad, i. e., do away with matter of human judgment.

2. Ways and means of predicting these conditions.

3. To know how near together climatic observation stations need to be located.

4. Where should station be located in particular fire zone where data needed, i. e., in yellow pine stand on south slope, another in open area, and still another in fir north slopes, or is a station in the adjacent valley sufficient?

5. An experiment station to help solve other problems as well as those of fire.

## Fire Problems in the Hardwood Forests of the Southern Appalachians

E. F. McCarthy

### Character of forest cover

Pure hardwood in the coves and on moist sites except in localities where white pine and hemlock are mixed in the stand. The spruce-fir type must be considered by itself. There is little in common between it and the true hardwood forest.

Dry sites have a large percentage of hard pine. Stands are open, timber too poor to permit logging except where chestnut forms the principal part of stand on the upper slopes and ridges.

The northern hardwood type on the higher moist slopes has more of the characteristics seen farther north, but lacks the snow protection.

This discussion refers chiefly to the typical southern hardwood forest with hard pine mixture, since these stands come more into contact with the causes of fire than the more remote higher types.

### Character of forest floor

Fires are carried largely in the leaf litter of the preceding season. Other litter and down timber serve to increase the intensity of fire but do not create a menace in themselves.

Slash is of minor importance in the general fire problem. It decomposes in 2 to 5 years. Where it is heaviest, the logging tears up the ground and creates natural breaks. By the time the new growth has reestablished the leaf litter over such areas, the slash has quite largely decomposed. Wood litter and down timber increase the damage to some extent.

Dry sites are dry for longer periods; are only regarded as waste areas by most people, and fire in them is regarded chiefly because of menace by its spread. The pine slash of these sites as well as other softwood slash must be regarded as a fire menace in itself. Grass and undergrowth are important fire carriers on the dry sites. There is no real duff, except a light one in some pine stands.

Characteristics of fire

Practically all are ground fires. Crown fires may occur in thick pine stands, and a similar type of fire may run through rhododendron and laurel thickets. This condition is limited to spots in the forest.

The steep slopes, deep leaf litter, and wind which is generally blowing in the fire seasons make the ground fires fast and hard to keep from the C class. Back drafts in the mountains cause fire to run readily in any direction. Only a head wind and down slope will check the fire in marked degree. Fire may jump at least a mile from a ridge top with favorable wind.

Leaf cover must be raked to make a break for control of fire. Soil is not a satisfactory means of combating fire. Water is not available unless pumps can be proved effective. Large areas are lost in back firing because of the necessity for starting in a gap to construct a line. Direct attack of the fire front would save a great deal of territory, and might be feasible if means of deadening the fire are found. Fire lines are hard to hold because of rolling burrs and cones which cross the line if not properly placed. Dead stubs are a menace in scattering fire. There are no natural breaks in the fire front, as is found in northern fires.

Seasonal variations

The average fire season - average of seven years on the Pisgah - is 65 days in the spring and 42 days in the fall. Growing vegetation and rains close the spring season about the first week in May, and the fall season starts when the leaf crop is down enough to furnish the fuel. Winter rains and high humidity close this season. Lack of rain in the absence of snow may cause winter fires, and summer drouth may cause summer fires. These are unusual. Spring and fall seasons fluctuate several weeks. Twenty-four hours of dry weather will create a fire hazard on dry sites, and three days a general hazard.

The latitudinal range of the Appalachians causes fluctuations in the time and duration of the fire seasons. The longest season in the south. Snow protection in the north.

Number and distribution of fires

Less accurate statistics than in western regions. Seven years average record for the eastern National Forests. For the Appalachian group. (Pa to Va.)

| | |
|---|---|
| Acres burned annually . . . . . . . | 439,055 |
| Number of fires . . . . . . . . . . | 3,446 |
| Acres per fire . . . . . . . . . . | 127 |

Six-year average for the 24 mountain counties of N. C. (State report, corrected for townships not reporting.)

| | | |
|---|---|---|
| Land area not improved, less 2% for roads, etc. . . | 4,791,378 | acres |
| Burned (187 twps. reporting) . . . . . . . . . . . | 102,000 | " |
| Burned (Estimate for 262 twps.) . . . . . . . . . . | 143,000 | " |
| Acres per fire . . . . . . . . . . . . . . . . . . | 168 | |
| Fires . . . . . . . . . . . . . . . . . . . . . . . | 606 | |
| Per cent burned of total . . . . . . . . . . . . . | 3 | |

Causes of fire in percentage. Ave. of 6 years for N. C. Average of 7 years for Appalachian group, National Forests.

| | Nat'l for. | N. C. |
|---|---|---|
| Brush burning | 12.2 | 24 |
| Hunters | | 13 |
| Campers | 12.3 | 3 |
| Railroads | 25.3 | 14 |
| Lumbering | 5.4 | 13 |
| Incendiary | 7.8 | 7 |
| Lightning | .5 | 1 |
| Miscel. | 5.4 | 3 |
| Unknown | 31.1 | 22 |
| Total | 100. | 100. |

Damage by fire

Seldom kills the forest completely, except in the spruce type.

Kills small size classes, wounds a larger percentage than is killed, inducing decay.

Stands are thinned out, crippled, and caused to sprout.

Damage to the forest floor, though not yet determined, is material, and the cause of reduction of site.

Poor stands are made poorer, decreasing the acreage that can be profitably managed.

Investigations required

Fire damage.

- Loss in cull timber through fire.
- Loss in yield, by site, through fire.
- Extent of insect and fungous injury following fire.
  - Continuation of mortality, especially in softwoods.

Time required to heal fire scars, especially in hardwoods.
Growth of reproduction under partial cover of fire damaged trees.
Relation of fire to yield.
Relation of fire to reproduction from stored seed.

Fire weather.

Studies of moisture in the forest floor as related to inflammability. Correlate with weather.
Test of combined storm movement prediction with field data on dryness of the forest floor.

## Fire Problems in the Northeast

S. T. Dana

The Northeast is characterized by a wide variety of forest types and a correspondingly wide variation in the fire danger. This runs from a minimum in old growth northern hardwoods to a maximum in cut-over spruce and pine lands, second growth spruce thickets, and pitch pine sand plains. Surprisingly severe fires also occur at times in the sprout hardwood types.

The most dangerous season is in the spring before the new leaves are out. At this time fires are likely to run freely in any type. The next most dangerous period occurs in the autumn after the leaves have fallen. Dry spells are, however, likely to cause bad outbreaks at any time between these two periods.

The most thickly settled parts of the region have both the greatest number of fires and the greatest per cent of forest area burned. On the other hand, more large fires, which occasionally attain the proportions of disastrous conflagrations, occur in the more inaccessible, unbroken stretches of forest in the wilder parts of the region.

Railroads, smokers, campers, and brush burning are the chief causes of forest fires. Lightning is a comparatively minor factor. While few fires are directly attributed to lumbering as such, many fires due to other causes undoubtedly originate in or are spread by cut-over areas.

Fire protection has reached a relatively high degree of efficiency in the region as a whole. During the past seven years the average area burned annually has varied from .04 of one per cent of the total forest area in Vermont to 2.78 per cent in Pennsylvania. The two outstanding problems are to reduce the number of fires in the more thickly settled parts of the region and the size of the fires in the wilder parts.

Education as a means of fire prevention is of outstanding importance. Thoroughgoing investigations along a number of lines are also much needed. The effectiveness and cost of different methods of handling slash should perhaps be placed first. Slash, and particularly softwood slash, undoubtedly increases the fire danger; but to what extent it does this, how much the danger is reduced by different methods of treatment, and what cost is justifiable in respect to the benefits derived, are important questions to which accurate answers are not available. The relation of slash to insects, disease, and reproduction is also a phase of the problem that cannot be overlooked.

Further information is much needed as to the relation between fire hazard and such factors as forest type, age of stand, logging conditions, population (both transient and permanent), location, and accessibility. Studies looking to the improvement of fire-fighting methods and equipment, and to securing prompter action by reducing elapsed time are highly desirable. Determination of the actual damage done by fires in different types and under different conditions, and the working out of simple methods of appraising fire damage, are important. The development of fire lines and protective strips, particularly along railroads, needs further study. Long and short range weather forecasting and the measurement of fire danger, while important, are probably less so than in some other regions.

The entire fire problem is one of outstanding interest to the State Foresters of the region. They can and should cooperate freely with the Experiment Station in its solution.

Discussion

Carter - Has the influence of wind on fires been overlooked?

Kotok - Its consideration has been merely held back thus far.

Osborne - The effect of wind is obvious and is passed over for that reason.

Show - Suggests that research results should be put in usable terms so that they may be practically applied.

Chapline - Called attention to influence of grazing on fire danger which would be brought out in a later paper.

Zon - Emphasized the influence of management on fire protection, stating that 15 cents per acre a year is necessary for good protection in Lake States in addition to 6 or 8 cents for taxes, and advanced the idea that partial cutting might cut the cost of production in half.

Factor or combination of factors giving the most satisfactory measure of fire danger; how determined; research under way and needed; methods and instruments; administrative application; etc.

## Relative Humidity as a Measure of Fire Danger
## Research Standpoint
J. V. Hofmann

I. Correlation of meteorological factors and forest conditions

1. Meteorological readings at Experiment Station:

a. Relative humidity with hygrograph, wet and dry bulb, sling psychrometer.
b. Evaporation - Standard Weather Bureau tank, Forest Service evaporimeters.
c. Wind velocity - anemometer recording.
d. Wind direction - wind vane recording.
e. Sunshine recorder.
f. Precipitation - tipping bucket, rain gauge, snow gauge.
g. Soil temperature - surface, 3 in., 1 ft. 2 ft. with soil thermometers.
h. Air temperatures - thermograph, standard maximum and minimum thermometers.
i. Air pressure - barograph, aneroid barometer.

2. Analysis of forest conditions.

a. Samples of more than forty forest materials have been used to show the response in moisture content to variations in relative humidity and other meteorological factors.
b. Samples taken from the forest and open areas.

II. Inflammability of forest materials in relation to relative humidity, precipitation, evaporation and other meteorological factors.

III. Variations in fire hazard due to type or materials; daily, periodic, and seasonal.

Diagrams were presented showing a close relation between relative humidity and inflammability of various materials in the forest. Below the line representing point of inflammability, fires make rapid progress; above this line they are easily controlled. After the grass and weeds are dead, a relative humidity below 25 per cent indicates a very dangerous condition; from approximately 25 to 60 per cent of the danger is moderate, while above 60 per cent it is slight. Records of temperature, evaporation, precipitation, and absolute humidity show a less consistent relation to fires than does relative humidity.

## Relative Humidity as a Measure of Fire Danger
## Administrative Standpoint

Wm. B. Osborne, Jr.

Subject studied from several entirely separate and distinct angles, as follows:

(a) Direct observation and deductions from scientific facts without the use of instruments.

(b) Study of all main meteorological factors preceding, during, and following the worst conflagrations which have occurred in various parts of the United States within the past 30 years.

(c) Study of fire history for entire seasons in comparison to main meteorological factors.

(d) Intensive investigations as carried on by J. V. Hofmann and covered in his paper.

(e) By utilization of sling psychrometers and hygrothermographs by field men.

Fields of application

1. For bringing about among all protective agencies and members of their organizations a more thorough realization of the very sudden and extreme changes in degree of hazard which can and do occur, together with a general knowledge of the primary causes of such changes.

2. For insuring a more intelligent execution of preventive measures, including the material increase of precautionary measures during easily determined periods of extreme hazard.

3. For permitting a more intelligent and efficient utilization of both protective and improvement forces on the basis of known variations in degrees of hazard existing.

4. For determining in a large degree the initial and followup action to be taken on established fires.

5. For determining definitely what methods of suppression should or should not be used on different sectors of a fire at different times of the day.

6. As a major consideration determining when burning permits should or should not be issued, at what time the burning should be done, and when by all means any outstanding permits should be canceled.

7. As a major factor in determining when and how slashings should be fired.

8. As a definite concrete factor to be predicted in the same manner as winds, rain, clouds, and temperature.

Experiences and sentiment of field men who have used equipment

The most urgent fields for further research work along this line are:

1. Studies of ways and means for securing longer predictions of subnormal ranges in humidity conditions.

2. More knowledge as to geographic range and details of interpretation.

3. The development of any other methods or equipment that may be used jointly or otherwise.

For several years the fire organization in District 6 has attempted to correlate the behavior of fires with various physical factors. Relative humidity has given the best relationship. All large fires in District 6 as well as in District 5 and in the Lake States have occurred during periods of extremely low relative humidity. These fires have not always been accompanied by severe drought or high wind. Mr. Osborne expressed the opinion that if loggers were made to understand that dangerous fire conditions can develop in a few hours they would be much more careful in handling fire, even going to the extent of shutting down their operations during periods of extreme hazard. He also pointed out the value of being able to anticipate the behavior of a fire in fighting it. It is not a question of whether relative humidity can be used; it is used. He considers wind important but less important and less easily measured than relative humidity.

Show called attention to the importance of wind in California, placing it above relative humidity because, throughout their fire season, relative humidity is usually low enough to create a dangerous condition, needing only a high wind to drive the fire beyond control.

Bates expressed the opinion that in the Southwest, relative humidity is habitually so much lower than in the Northwest that daily variations have much less effect.

Pearson--in District 3 the rise in relative humidity accompanying the usual low night temperatures undoubtedly checks the progress of grass fires.

## Use of Moisture Content of Duff or Other Fuels as a Measure of Fire Danger
### Research Standpoint
H. T. Gisborne

Fire danger fluctuates directly with degree of inflammability, which in turn changes with moisture content of the fuels. All of the fuels do not have the same moisture content at any specific time, and they are of unequal importance in catching and carrying fire. The following table shows the moisture contents of several important fuels in the white pine type as determined during the driest part of the first week of the months shown.

| Material | 1922 June | 1922 July | 1922 Aug. | 1923 May | 1923 June | 1923 Jul. | 1923 Aug. | 1923 Sept. | Ave. |
|---|---|---|---|---|---|---|---|---|---|
| | Moisture Content in Per Cent | | | | | | | | |
| Twigs | 9 | 6 | 7 | 12 | 20 | 14 | 12 | 16 | 12 |
| Top layer duff | 12 | 9 | 7 | 18 | 55 | 16 | 14 | 19 | 19 |
| Full " " | 20 | 13 | 9 | 167 | 182 | 57 | 24 | 30 | 63 |
| Outside 1/2 inch wood on windfall | 155 | 30 | 17 | 111 | 216 | 129 | 28 | 17 | 88 |

In the white pine type in northern Idaho the top layer of duff covers more surface area, catches and carries more fire than any other fuel. The above table shows it to be consistently the next to the driest of these important fuels, hence a reliable, but not radical, index of prevailing conditions.

The duff hygrometer designed for measuring moisture content in the duff was tested for 60 consecutive days and found reliable. Results are shown on the photostat chart attached. This method has been tried out only in the white pine timber type so far. It has not yet been determined how this method will work in other types, with other fuel combinations.

The ease of ignition varies directly with the dryness of the duff. An instrument designed by Mr. Dunlap of the Products Laboratory shows the relative moisture content of the duff without the necessity of weighing and drying samples. The instrument may be inserted in such a way as to come in contact only with a thin surface layer. It is left in place, and then indicates the condition of the duff at any time. It responds within a few minutes to changes in moisture content. Gisborne has tried various factors, including evaporation and relative humidity, but finds none so closely related to fire hazard as moisture content of the duff. He does not regard the present instrument as suitable for measuring the moisture content of grass and weeds, but states that they rarely encounter this condition in District 1.

Kelley points out that in District 1 fires are readily controlled if they can be kept on the ground. If the litter is dry, however, the fire quickly goes into the crowns. He suggests that the condition of the litter may be more important in District 1 than in District 6.

## Use of Moisture Content of Duff or other Fuels as a Measure of Fire Danger
### Administrative Standpoint
Howard R. Flint

An adequate and reliable measure of forest fire danger is needed by all field men in District 1.

Such a measure will be one that will give a check on judgment or replace judgment with something more definite and dependable.

The judgment of administrative men is now practically the sole basis for all fire action that is undertaken.

On the effectiveness of such action depends the safety of twenty-two million acres of National Forest in D-1, having tangible values in excess of one hundred forty million dollars, and involving an average annual expenditure, including losses, of about two and one-half million dollars.

Experience, individual or collective, is the basis for judgment. The man without experience has no basis for individual judgment.

Lacking a record, experience is possible only through memory.

A cumulative record of instrumental measurements is far more dependable than a memory of conditions not clearly defined. From the administrative standpoint it should be one of the functions of Research in fire to:

1. Determine specifically what records are essential.

2. Develop the most simple means of securing them.

3. Show how to apply them to the task in hand.

Preliminary studies by Larson in D-1 and by several others in other Districts seem to indicate that the start, rate of spread, and intensity of fires depends chiefly on the moisture content of the important fuels, therefore, an adequate and comprehensive record of that factor is of the greatest importance to the administrative forces.

Direct measurement and records of the moisture content of the fuels in place is desirable because it can be localized to apply to varying type, exposure and altitude conditions. There are in D-1 six fairly well defined regions between any two of which fire danger may vary considerably at a given time.

Since the administrative man must in a great majority of cases use his judgment or his available records to prepare for fuel conditions that will exist in the future, such judgment or records necessarily become the basis of a forecast.

Lack of forecasts or inaccurate forecasts of fuel conditions have cost us many thousands of dollars in the past.

Two general types of reliable forecasts are needed, as follows:

1. Long range forecasts covering the general character of the season.

2. Detailed and definite forecasts of the fuel and weather conditions during the next two or three days following the forecast.

Forecasts of Type 1 would be useful in:

Planning and putting on the season's protective organization.

Preparing and mobilizing special equipment.

Issuing special and definite warnings in advance to forest users and to the public.

Forecasts of Type 2 would be useful in:

Determining the time of placing emergency men and the number of such men needed.

Determining the number of men to hold on going fires or send to going fires and predicting the period of time for which they will be required.

Providing for the mobilization of tools, equipment and supplies.

Deciding when to issue or withhold burning permits.

Controlling slash disposal and logging operations to eliminate or reduce fire danger due to them.

Holding protection and suppression expenditures to the minimum sums which will accomplish the desired results.

For the purposes outlined above it is highly desirable that forecasts be dependable for 80 per cent or more of the periods covered. Forecasts of a less degree of dependability will be useful in proportionate degree as checks on judgment.

When the measurement and forecasting of fire danger is developed to the extent indicated above, for one locality or region in D-1, it will be desirable to extend like activities to at least two other localities in the District which are under different conditions.

With instruments reporting by wire from several localities, one qualified forecaster can probably furnish by wire or radio all forecasts needed for the District.

## Discussion

We need a measuring stick to check judgment and also experience to apply measurements. Flint supported Gisborne's conclusion that moisture content of the duff is the best index of fire hazard in District 1. Gisborne has applied data on duff moisture in handling fires, but has not found a way to apply relative humidity. Referring to Osborne's statement that in District 6 fire periods often end without rain, he stated that in District 1 the fire season never ends without rain. (Hofmann later called attention to the distinction between fire periods and fire seasons. The fire season in District 6 usually ends with rain, but this is not always the case with fire periods.)

Greeley - The relative humidity at a given time ought to indicate what the moisture of the duff will be several hours hence.

Gisborne - We must know how wet the duff is to begin with in order to predict what the air is going to do to it.

## Vapor Pressure as a Measure of Fire Danger

E. F. McCarthy

Relative value as an indicator of fire hazard.

Not an indicator by itself.

It is valuable in showing the trend of atmospheric moisture content at each successive reading without reference to the air temperature.

Definition of vapor pressure. Discussion.

1. Measurement in terms of mercuric inches.
2. Relation of saturated aqueous vapor to temperature variation.
3. Variation of vapor pressure as related to dew point temperatures.
4. Seasonal range of vapor pressure.
   Comparison of the mean relative humidity curve to vapor pressure.

Weather conditions which accompany changes in vapor pressure as cause or effect.

1. Change in air pressure.
2. " " temperature.
3. " " wind direction.
4. Relative humidity.
5. Precipitation.

Observed correlation of fire occurrence and vapor pressure reduction.

Practical value of vapor pressure in forecast.

1. Place is secondary to the movement of storms.
2. Combination of reading of vapor pressure and saturation deficit, furnish more information than the most careful plotting of relative humidity.
3. Rains due to the "mountain influence" are the result of high humidity, which causes precipitation at the time of the change of wind direction.
4. Until a curve of forest dryness supplants this, there is no graphic way of showing the duration and trend of atmospheric dryness.

## Discussion

In the hardwoods of the Appalachian region the fire menace is created by the leaves after they drop in the autumn. Vapor pressure (absolute humidity) is not a specific measure of fire danger, because its drying effect varies with temperature. When temperature falls, vapor pressure falls. Vapor pressure fluctuates periodically rather than diurnally. The changes are associated with cyclonic storms, the highest vapor pressure occurring during periods of low atmospheric pressure. McCarthy has based his investigations on a comparison of fire occurrence with Weather Bureau records and weather maps. He stated that a single reading of vapor pressure gives the general trend; relative humidity requires a series of readings.

Hofmann- One or two readings of relative humidity per day are of little value. We need frequent readings, preferably records from a hygrograph.

Osborne - Relative humidity is a combination of vapor pressure and temperature. Vapor pressure alone, without temperature, tells little.

Evaporation as a Measure of Fire Danger

Research Standpoint

C. G. Bates

1. The measurement of evaporation as an index to the fire danger is in essence merely a means of measuring the ups and downs of the weather cycles, which are qualitatively shown by the areas of high and low pressure, wind directions, etc., on the daily weather maps of the Weather Bureau. If we conceive of these cycles as waves having a frequency of about 7 days, the advantage of the evaporation record is in determining not only qualitatively the occurrence of ups and downs, but quantitatively the actual amplitude of each wave. A further value of the evaporation chart is in showing the cumulative values of the evaporation since the last soaking rain.

2. It may be questioned whether the Weather Bureau data cannot furnish the same information. There is no means by which the Weather Bureau information can be reduced to a single quantitative expression of dryness. The evaporation record simply integrates all of the factors which contribute to drying. It is true that vapor pressure or relative humidity is the greatest single factor in drying, but it is not the only one.

3. The method by which the evaporation record may be applied to a study of the current fire danger is indicated by the records obtained in D-2 during 1923, although the season was very wet and the number of fires occurring was insufficient to establish the relationship beyond question. It appeats from this record that it is not the current daily rate of evaporation which measures fire risk (this being comparable to the current humidity) but, at least roughly, the cumulative amount of evaporation since the last soaking rain. The fact that our curve of evaporation has passed its peak and started to decline, does not relieve us of fire danger, as might be suggested by the data of the "humidists." A very low point in evaporation may be reached, corresponding to a low barometric pressure, but if rain does not occur, the fire danger still exists. Consider the evaporation record for Fremont and the Pike Forest record for fires. The former indicates that the high point of evaporation is the fourth day after a low. Of 11 fires recorded, the only Class C fire of the season occurred May 2 in a cycle which began April 26 and ended May 3. One Class A occurred on the third day of a cycle, before the peak, another similarly on the fourth day. A group of 7 fires occurred in the cycle beginning June 28, 4 before the peak (July 3 and 4) and 3 after it, July 7 and 8. But this cycle was the fourth in a succession which had not been divided by any really wet weather. Here we have the cumulative effect shown in a marked degree, though of course this is a particularly bad time for fires.

The next fullest record is that for the Black Hills. Here we find one fire on the first and one on the second day of a cycle, the former representing a "dry low" and the latter a wet one as indicated by evaporation, but actually wet only to the extent of a heavy mist. All of the remaining eight fires occurred after the peaks of their respective cycles.

If we consider the average daily evaporation for cycles which produced fires (15.2 gms. per day), it is slightly greater than the average for the days on which fires occurred (14.0 gms. per day). Therefore it must be clearly apparent that it is not the high peak of the cycle which produces a special danger, but the cumulative effect which may exist after a high peak and even after a decided low which is not accompanied by heavy rain.

4. It is, therefore, useless to attempt to analyze the average character of one of these cycles. In fact, they are so variable that they do not submit readily to statistical treatment. It is very doubtful as to whether we can even properly sum up the cumulative effects of drying in a single term and in such a way as to have practical value, because this cumulative effect may have accrued over several weather cycles, and unless we know that a low evaporation period produced a soaking rain, we are not sure that the cumulative effect of drying has been entirely dissipated. Perhaps after more experience we can rate the value of rainfall, but certainly not now.

5. On the other hand, it is believed that the graphic record (such as will be shown) presents, in the hands of the interested forest officer, a comparatively simple index which can be interpreted with a little judgment. The officer needs, for effective use of this graph, a knowledge of the rainfall which has occurred so that he can quite definitely delimit the beginning of a new period of calculations. The cumulative record of drying then pretty well tells the whole story.

6. From the purely research standpoint I cannot see that this method involves us in very much except the instrumental part, that is, providing the forest officers with evaporimeters that can be relied upon and instructing them in the use of the instruments. It is true that if Research could act as a clearing house for the records of a number of stations reporting telegraphically, a broader and perhaps a better interpretation might be placed on the data, but research would suffer the disadvantage of having only meager data as to the character of the rainfall, and the local forest officer would not be so much inclined to combine his local knowledge with a study of the evaporation chart.

Evaporation sums up all drying factors. It fluctuates more or less in cycles of several days corresponding to periods of high and low atmospheric pressure. Plotting the daily evaporation losses gives a series of fairly well defined crests and troughs. The greatest number of fires occur on the crests. By noting the trend of the graph it is usually possible to predict which way it is going during the next day or two. Weather Bureau data can probably be employed to indicate the above changes, but we have no means of reducing Weather Bureau data to a single quantitative expression of dryness. Vapor pressure, as Munns has indicated, is the greatest single factor but is not the only one.

## Evaporation as a Measure of Fire Danger

### Administrative Standpoint

E. I. Kotok

A. Method used in California for three seasons

1. Atmometer, porous cup type, 15 stations.
2. Bates' evaporimeter, 5 stations.

B. Comparison of instruments from the standpoint of use by field officers

1. Atmometer.
   (a) Easier instrument to read with untrained personnel.
   (b) Greater chances for instrumental error,- by clogging.
   (c) Failure to fill instrument with water frequent, when evaporation increases suddenly.
   (d) Failure to place instrument in correct exposure - instrument easily affected by local conditions.
   (e) Easily broken.

2. Bates' evaporimeter.
   (a) More reliable results under trying conditions.
   (b) No exact comparisons possible between two instruments - not sufficiently standardized.
   (c) Requires more care in use.

C. General Comments

1. Even if good data are secured from either instrument, field officers not always qualified to interpret.

2. Best possibility, if regional readings are sufficient, to use central stations which should secure and interpret all meteorological data and then broadcast fire weather forecasts.

3. Field officers better equipped to handle warnings than make interpretations of regional data.

4. Use of instrument has so far been beneficial in getting field officers to think in terms of fire weather. In some instances skillful application of local readings has materially assisted in handling fire situation.

In California evaporation records have been kept with both the Livingston atmometer and the Bates evaporimeter. Some difficulty has been experienced in securing reliable records. The atmometers have shown a tendency to clog. The evaporimeters in some cases have not been adequately standardized. To some extent the trouble has been due to carelessness on the part of the forest officers in charge of the instruments. Several supervisors have made good use of the instruments, both in securing reliable records and in applying them. In many cases, however, field men have not known how to interpret the data.

# Interrelation of Climatic Factors as Affecting Forest Fires in California

S. B. Show

1. The Problem

    1. To define effects of fire weather, i. e., rate of spread.
    2. The effect of individual climatic factors on rate of spread.
    3. The regional extent of major fluctuations of weather.
    4. The response of fuels to climatic elements.
    5. The value of different instruments and climatic indices as a basis for forecasts.
    6. The possibility and value of regional vs. local forecasts.

2. Regional Fluctuations

    1. Climatic elements.
    2. Spread of fires.
    3. Broad scale relations.

3. Climatic Elements and Rate of Spread

    1. Wind.
    2. Humidity.
    3. Vapor pressure.
    4. Combinations.

4. Use of Instruments and Different Climatic Elements as Forecast Basis

    1. Atmometers and evaporimeters - evaporation.
    2. Psychrometers and hygrographs - humidity.
    3. Vapor pressure.
    4. Other.

5. Forecasts

    1. Regional - facilities of Weather Bureau.
    2. Local - possibilities and limitations.
    3. Long range forecasts.

6. Needed Investigations

    1. Exact relation of weather factors to fuels and rate of spread.
    2. Regional difference in response of various fuels to different factors and combinations.
    3. Definition of fire weather and similar terms.
    4. Possibility of long-range forecasts.
    5. Influence of long and short period fluctuations.

Kotok - District 5 has used Weather Bureau data on wind and relative humidity, in addition to Forest Service records of evaporations. These data have been correlated with the occurrence and intensity of fires. Plotting the daily occurrence of fires has brought out the surprising information that fires occur somewhere in the District every day during the fire season. The general trend of evaporation and relative humidity is the same in mountains and valleys. Relative humidity alone has a decided effect upon fires, but the most serious condition occurs when low relative humidity is accompanied by high wind. It is this combination of conditions which we should be able to predict. The course of evaporation indicates the general course of fires, but there is no specific relation between evaporation and the rate of spread of fires.

Mr. Cox of the Weather Bureau cautioned against placing implicit confidence in Weather Bureau records of wind, humidity and precipitation. All of these records apply to the particular spot on which the instruments are set up, but not always to the locality which they represent. Inversions of the normal temperature gradient may have a strong effect upon relative humidity. He expressed the opinion that the best index of fire conditions is low absolute humidity under conditions of low relative humidity.

Kelley called attention to the extremely low humidities of the Southwest -- far below the danger point in District 6, asking why we do not have a worse fire situation in the Southwest. He suggested that a different scale of relative humidities should be applied in the Southwest.

Pearson stated that the relatively low fire hazard in District 3 is due to the sparsity of inflammable material. With the exception of slash areas, the amount of combustible material on the ground is small as compared with the Northwest. Grass rarely covers more than one-third of the ground surface, usually much less; litter is not sufficient to create a serious menace; the stands in the yellow pine type are rarely sufficiently dense to produce a crown fire. Both relative humidity and wind, however, are important in relation to rate of spread. Fires are much easier to control at night, due to a lowered relative humidity accompanying the lower temperatures prevailing at night.

Reliability of the hygrograph was made the subject of discussion. Pearson, Gisborne and Cox stated that according to their experience the instrument is unreliable unless checked several times each day. Hofmann stated that he had secured very satisfactory records with the instrument.

Gisborne cited records which indicated that moss burned freely when the relative humidity was 90 per cent. Hofmann pointed out that in this instance the relative humidity reading was made nearly two hours before the burning test, and that in reality the relative humidity was much lower than indicated.

Dana suggested the use of more direct tests, such as actually applying a match to litter, moss, etc., instead of instruments. Osborne replied that in District 1 they are using the direct tests, but also need the instruments to measure invisible conditions such as relative humidity.

3. The forecasting of fire danger as so far developed; factors or combination of factors; functions of the Weather Bureau, of the Forest Service, etc.; research under way and needed; methods and instruments; administration, application, etc.

## Forecasting of Fire Danger
## As Developed at the Wind River Station

J. V. Hofmann

(a) Basis for Prediction

1. Seasonal and daily condition of forest materials.
2. Humidity curve, hourly, daily, and periodic.
3. Weather Bureau forecasts.
4. Static Electricity.

(b) Purpose of Prediction

1. To determine method of procedure on existing fires.
2. To keep public interest in proper relation to fire hazard.
3. To direct protection forces.
4. To determine best time for undertaking necessary burning, such as slash burning, permits for land clearing, etc.

(c) Period of Prediction

1. Daily based on relative humidity and other meteorological factors.
2. Periods of two or three days based on Weather Bureau forecasts.
3. Periods of safety due to precipitation or seasonal conditions.

(d) Method

a. Broadcasting through Oregonian radio station KGW, Portland, Oregon.

b. Telephone and telegraph in specific cases.

The humidity of the air as well as the moisture content of dead vegetation changes very rapidly. Dead ferns may be soaking wet at 5:00 a. m., yet by 8:00 a. m. they may be dry enough to burn. If relative humidity takes a continuous downward shoot early in the morning it indicates fire danger; if, on the other hand, it fluctuates up and down the

indications are favorable. Normally the relative humidity at night is high in the Northwest. Low relative humidity at night indicates the approach of a dangerous condition. This condition preceded the big fire of 1922 and the Berkeley fire of 1924.

Tiemann - The Weather Bureau can predict temperatures and absolute humidity. Relative humidity is the factor of most direct application. Since it is a combination of temperature and absolute humidity it can be predicted indirectly through these factors.

Kelley - The day before the Berkeley fire last September I slept on the boat docks at Port Costa. From the way I felt that night I knew we would have a severe fire condition the next day.

Carter - We don't need instruments as long as Kelley will sleep on the docks and give us the warnings we want.

## Forecasting of Fire Danger as Developed at the Priest River Forest Experiment Station

H. T. Gisborne

The differences between weather forecasts and fire forecasts must be clearly defined before it is possible to discuss the factors involved, the functions of the Weather Bureau, or the method of application of forecasts.

Weather forecasts from the Weather Bureau are designed to show the probable weather for a certain area, during a certain period of time, and in our region have a general dependability of about 80%. Fire forecasts are needed to show the probable effects of this weather in the district fire types of the same region, during the same period of time and with a dependability of at least 80%. Weather is the cause, fire danger is the result, and the preparation of fire forecasts require accurate translation from cause to effect. If it were true that the same quantity and quality of weather always produced the same degree of fire danger the translation would be very simple. Unfortunately, the degree of fire danger prevailing at any time has a profound effect on the result to be expected from the weather. The timber type, density, exposure, etc., also exert modifying influences. Consequently, a certain weather condition sweeping over any big area will usually cause a different total effect each time, as well as different effects in each of the individual areas. The object of fire forecasts is to state these expected differences with sufficient detail and accuracy to permit more detailed and more accurate fire protection. If we merely take a 36-hour weather forecast reading as follows: "Continued fair with slowly rising temperature, moderate southwesterly winds," and re-issue it as a fire forecast stating that, "Fire danger can be expected to increase during the next 36 hours," we have not made any great step in advance. Any Forest officer is capable of making such a translation. Research is supposed to go into greater detail and administration can certainly make use of greater refinements.

In northern Idaho we should be able to take the above weather forecast and employ the immediate steps which will enable us to notify the Supervisor that: "Fire danger tomorrow afternoon can be expected to be low on the northerly timbered slopes, medium on the open north and flat timbered areas, and high on all south exposures between 2,000 and 4,000 feet elevation. Above 4,000 feet only the more open south slopes will be inflammable." And a few days later: "Two more days of the present weather can be expected to result in extreme inflammability on all areas below 3,000 feet elevation. High inflammability will prevail above that elevation. There is a strong probability that two such days will occur and will be followed by electrical storms." Such forecasts are specific and justify specific protective measures if they are accurate. We are aiming our work at just such a goal. Achievement of success will require three things; accurate knowledge of existing inflammability in all distinct fire types at various elevations; second, accurate and detailed weather forecasts; third, accurate and detailed knowledge of the effect of any combination of weather elements on any existing degree of inflammability.

As outlined, we believe we are now able to measure existing inflammability in all the timber types in which duff is an important fuel, and at any elevation. We must extend to cover the open, cut-over, and burned areas before our method will be complete. Evaporation measurements may serve on such areas better than our instrumental method but neither one has been given a test.

The second requirement consists of accurate and detailed weather forecasts. This is going to be our stumbling block. The information is fundamental to our progress yet the best forecasts available today are hardly equal to our present requirements and it is very doubtful if progress in weather forecasting will keep pace with our progress in the application of such material.

Several sources of weather forecasts and reports are available today. The principal source is the U. S. Weather Bureau, willing to coöperate with us in every way possible by furnishing both specific forecasts for any region and reports of weather conditions at their stations so that we can frame our own forecasts. An attempt is also being made to assign Weather Bureau meteorologists to the various forest regions of the West and to study the problem of forecasting as has been done with frost prediction for the orchard and vegetable regions. The Weather Bureau forecasts and reports can be obtained by wire or by wireless.

Last season we received 36-hour forecasts by wire every day from July 1 to September 15 and they were dependable about 77 days out of 100. Next season we plan to receive the reports as well as forecasts by radio phone. Wire reports were received once each day, radio reports are broadcast twice a day, except Sundays and holidays. There are advantages and disadvantages to both methods of reception. After giving radio a thorough trial we will be in a better position to supply detailed recommendations.

A second source of weather forecasts consists of local measurements of all the weather elements coupled with reports and forecasts issued by the Weather Bureau. Local measurements are of small value when used alone but they help tremendously in determining the action to be taken on the Weather Bureau forecasts. The more knowledge of meteorology possessed by the forest forecaster, the better his chance of success, of course.

A third source of weather forecasts available on the Pacific Coast consists of a magazine called the "Sunspot" issued by Father Ricard of the University of Santa Clara and containing forecasts by days for the ensuing month. Some of the Ricard forecasts are decidedly vague; others are fairly clear; all of them are mainly for the Pacific Coast and have to be modified slightly before they can be applied in northern Idaho. They foretold our conditions remarkably well during the past summer nevertheless.

Our method of using the Ricard forecasts consisted of checking them against prevailing weather and if the forecasts during the past few days had come true we made use of those ahead for periods up to 10 days. If the forecasts seemed to be off we merely waited till they began to check out again. On this basis we were able to supply four or five 3 to 10-day forecasts to the Supervisor last season all of which were substantially correct. They included a three-day warning of lightning storms in two cases and a warning of ten days of decidedly unusual drought in September.

A fourth possibility of weather forecasts consists of experience charts of precipitation, temperature, etc., by ten-day or shorter periods. Such information is undoubtedly reliable in the long run and shows graphically for the entire season when to look for waves of precipitation or waves of drought and high temperature. For our station this chart shows that the last ten days of July and the last ten of August are shown to be, as a rule, the periods of greatest danger. This chart was 80% dependable in forecasting more than a certain amount of rain for the 15 ten-day periods at Priest River last summer. It was only 66% dependable in forecasting less than a certain amount of rain for each period.

The third essential for successful forecasting of fire danger consists of accurate and detailed knowledge of the effects of any combination of weather elements on any existing degree of inflammability. This means that, given a reliable forecast specifying a certain temperature, humidity, and wind velocity condition during the next 36 hours, we must be able to state what that will do to an average fuel moisture content of say 10% on the south slope, and 20% on the north slope. Likewise, if a certain amount of rain can be forecast we must be able to specify its effect according to prevailing moisture contents on the various exposures.

Larsen gave considerable study to these processes when he was conducting fire studies at Priest River. Larsen has presented a chart showing the possibility of converting records of sunshine, temperature,

humidity, and wind velocity into one resultant, evaporation. It seems that we should have similar information carried logically through to the resultant degree of inflammability. Perhaps even to rate of spread of fire this can be done with the present information. It is applicable, however, only on clear days when effects of precipitation have disappeared and materials are nearly in equilibrium with diurnal changes of the atmosphere.

In order to carry out this possibility and determine the probable application in actual practice, we have been attempting to isolate the effects of the various weather elements on moisture content of fuels at Priest River. We have preliminary curves showing effect of various amounts of precipitation per 24 hours; effect of various rates of evaporation according to length of period of drying, and moisture content of fuels at the beginning of the period; saturation capacity of duff, and the ability of duff to absorb moisture by capillary action. The Madison Laboratory has also determined the fundamental relations between moisture content of several fuels and the temperature and humidity of surrounding air when cause and effect are in equilibrium. We have an instrument constructed for the special purpose of tracing a curve of moisture content of a material according to surrounding atmospheric conditions. The purpose of this instrument was to obtain curves of actual moisture content and compare them with curves of equilibrium moisture content for the temperatures and humidities experienced so that the lag of response can be determined. In short, we are trying to build up a basis for interpreting weather forecasts into fire forecasts, our results being only tentative indications as yet.

So far our only actual experience in preparing fire forecasts has consisted of a trial of forecasting the trend, and amount of change, of the curve of inflammability obtained for the white pine type by use of the duff hygrometer. Each evening from August 1 to September 16, when the duff moisture content was measured and plotted for that day, a forecast was written down stating the degree of inflammability which seemed probable 24 hours later, on the basis of the Weather Bureau forecast for the same period. Forty-six consecutive forecasts were obtained. Mr. Flint has rated them for dependability and gives us a percentage of 78 days out of 100 as reliable.

These forecasts, while very specific in nature, were based on a specific measurement of existing inflammability, but only a very general weather forecast. We are already in a position to use much more detailed forecasts than can be given us at present by the Weather Bureau. Our accuracy of course cannot greatly exceed their accuracy.

## Forecasting of Fire Danger
## As Developed at the Appalachian Station
E. F. McCarthy

### Apparent need

1. An organization of state and national fire forces capable of expansion to meet sudden emergencies, to utilize the benefits of a fire weather forecast. This will require a more perfect organization on the part of the states, and possibly on some of the National Forests.

2. A forecast service that will keep informed of the hazard and when it approaches a condition to warrant, will begin the distribution of forecast warnings which will furnish the field force with the basis for expansion of the protective force.

The period during which such forecasts will be needed should cover for this region about ten weeks in the spring and six in the fall. Such forecast should be sent out at least 2 days in advance, and should be continued as long as the hazard exists.

### Present work of the Weather Bureau

Forecasts are issued about 10.00 a. m., compiled from the 8.00 a. m. records, and cover a period about 34 hours in advance. This is the regular forecast service.

General forecasts are made to cover the succeeding week and show the general character of the weather without reference to the exact time of occurrence.

No special fire weather forecasts are made for the Appalachian region, although this is done for other regions.

### Conditions of weather favoring fire

A period during which high pressure is established over the Appalachian region or to the west of it, inducing dry, northwesterly or westerly winds. Such a condition may arise because of the continuation of a high pressure condition across the southern part of the U. S. while storms are moving to the north, or it may result from a minimum of storm movement, with a flat pressure gradient over the country. The period during which the average high pressure zone remains usually covers only two to three days, and this is not enough to bring about unusually dry conditions.

The most severe part of the fire season comes after the cessation of the frequent tropical cyclones which take extra tropical form and move across the lower part of the south, or pass up the Mississippi Valley.

Conditions unfavorable to fire

Periods of frequent gulf disturbances.

Periods of south winds, even without rain. This occurs when storms are passing farther north, and the winds coming from the Gulf or Atlantic regions are humid.

Some seasons, such as the fall of 1923, may have a generally high humidity, such that rains are caused in the mountain sections without the passage of a low pressure area close to the region. This condition may be related to the occurrence of high surface water temperatures in the Gulf of Mexico.

Accuracy of forecast

When storms are of the northern Rocky Mountain type, they are mapped and followed for a period of three days before they influence the precipitation of the Appalachian region. This makes possible a very good degree of accuracy in forecast for this period in advance. In addition, they usually cause the wind to shift to the south in advance of the storm, which in itself is unfavorable to the severe type of fire.

Storms of the Gulf type can arrive in this region in a period of about 36 hours from the time they are defined over the Gulf or over Mexico. This reduces the certainty of prediction to this period as its limit, though such storms are not frequent during the later part of the fall fire season.

Function of the Weather Bureau

The forecast service must be carried on by some such agency as the Weather Bureau, which has the benefit of all the telegraphic reports received at Washington. A forecast service will find the seasons of fire danger are so distributed through the U. S. that attention can be given to the southeast at a time when other regions are not so liable to burn. During the spring and fall seasons, forecasts should include storm movement, precipitation, wind direction and velocity, and humidity, to cover a period at least two days in advance, and issued daily. While this might cause some uncertainty in regard to gulf storms, the daily forecast would allow the correction of the two-day forecast in this case, just as a twelve-hour correction is now possible.

Function of the Forest Service

The correlation of forecasts of weather conditions to the condition of the forest. This will involve the establishment of field stations to report on the dryness of the forest floor, to take the place of the occular judgment now used.

Distribution of the complete forecast to the field force and possibly to state offices.

Research accomplished

Study of fire occurrence and weather sequence of the two past fall fire seasons.

Research needed

Selection of a number of periods of severe fire hazard as shown by the past records, and comparison of these to determine the sequence of weather conditions which produced the hazard. This will be most readily accomplished at Washington where the fire records and weather records can be studied without requisition of a large number of weather maps.

Study of forest inflammability, by some such method as that used with the Duff hygrometer. Correlation of weather conditions with studies of inflammability may make unnecessary the permanent maintenance of forest observations.

Development of a code of report that will have a definite meaning to the field force.

The general discussion showed that the basis for forecasting is Weather Bureau maps, pressure areas, winds, etc. By observing the behavior of storms as they travel across the country from west to east, McCarthy believed it possible to make fairly reliable predictions three days in advance in the Appalachian region. The accuracy he attained during the first season in such predictions was 60 per cent. He believes that with further experience this percentage can be increased. McCarthy gave a demonstration of how predictions are made by pointing out the daily progress of storms on a series of weather maps.

## Theory of Probabilities in Relation to Climatic Cycles as Developed in Russia

Raphael Zon

The Russian Weather Service has worked out charts for the prediction of the occurrence of drouth in agricultural districts.

The principle employed in the preparation of these charts is suggestive in working out plans for the prediction of the probable occurrence of dangerous fire periods.

The Russian charts are based on the amount of precipitation that fell in one rainfall or several in a given locality during every 10-day period. The prediction extends for every 10-day period beginning with April 1 to the end of October, a period very similar to the fire season period in the northern and northeastern parts of the United States.

Precipitation has been accepted as the principal climatic factor in basing predictions, although the temperature or the isotherms are also indicated on the charts.

A condition of drouth is assumed to exist where the total precipitation during any 10-day period within the months of April to October did not exceed one-fifth of an inch.

The charts were based on climatic observations secured at over 400 meteorological stations. No station which had observations for less than 10 years was used. The average period of observations extended for 17 years.

The prediction is based on the theory of probability.

The probability of the occurrence of a certain phenomenon is the ratio between the number of actual occurrences and the number of possible occurrences. If this ratio is multiplied by 100, the probability of occurrence of a certain thing is expressed as a percentage. Thus, for instance, if at any meteorological station, for which there are 16 years' observations, there actually occurred 16 drouths during the first, say, 10 days in April, the ratio is as 16:16. This multiplied by 100 gives 100. In other words, according to the theory of probability, the chances that the same thing will occur again are 100 per cent. If, on the other hand, after 16 years of observations there actually occurred eight out of the possible sixteen, the probability is 8:16 multiplied by 100, or 50. The chances are even that the same thing will occur again.

For each station the probability of the occurrence of drouth conditions was worked up in percentages. The probability of occurrence was divided into three groups, one from 0 to 30, one from 30 to 70, and one from 70 to 100. These different degrees of probability are shown on the charts by three different colors for every 10-day period, or 21 charts in all.

Although precipitation was the principal climatic factor upon which prediction was based, temperature was considered of importance since the fire danger with the same amount of precipitation sometimes increases with higher temperatures and sometimes increases with lower temperatures. In the spring and summer, for instance, with a certain amount of precipitation the fire danger increases with increasing temperature. In the fall during a drouth the fire danger is greater when the temperature is lower or even when killing frosts have occurred and, therefore, the vegetation is dead and more inflammable.

There is a possibility that such a basis for the prediction of the occurrence of forest fire periods is possible for the Lake States. In the region there are no lightning fires and the precipitation, on account of the region being in the path of storms and the absence of high mountains, when it does occur is rather general. Drouths are often accompanied by high temperature, increased evaporation, etc., but these elements, no matter how influential, simply accompany the drouth and are secondary phenomena. If there is a sufficient amount of precipitation, their effect is greatly modified.

An attempt was made to correlate precipitation data and occurrence of fires in the lower peninsula of Michigan with very good results. On the charts presented here for the months of April, May, June and July, the occurrence of precipitation of over one-half inch shows the disappearance of fires. With the fall of precipitation below one-half inch, the fires increased.

(Zon referred to a series of charts in which the rainfall over a period of years was plotted by 10-day periods. The probability of drought at any time is indicated by the frequency of past occurrence during the period in question.)

## Rainfall Cycles in Relation to Fire Control

G. A. Pearson

I. Do Rainfall Cycles Exist?

1. It seems pretty well established that they do.
2. We have a 11.4 year cycle and multiples of twice and thrice this number; also 7.7 year and 100% cycles - Douglass.
3. The maxima and minima of the rainfall curve are very irregular. It requires smoothing to bring out anything like well defined crests and troughs. The crest occurs where the average annual rainfall for 5 or 6 years is above normal. Very often in the Southwest 2 or more of these years are far below normal.
4. It is possible to predict an excess or a deficiency for a period of 5 years, but not for a single year. The very year in which the maximum should fall according to calculations may prove to be the driest in the cycle.
5. Local variations in precipitation records for neighboring stations may agree over a series of years, but discrepancies occur in single years.
6. Rainfall cycles may apply roughly to the country as a whole, but may not fit a given locality. Local disturbances are common in mountain regions.

II. What is the Relation between Rainfall and Fires?

1. A general relation may be assumed, but we cannot draw a definite line.
2. The calendar year is an unsatisfactory unit. Douglass uses Nov. 1 - October 30, or Sept. 1 - Aug. 31.
3. Total annual precipitation is not a reliable index of conditions during the fire season.

   In D-3 the main fire season is May-June.
   Annual and May-June precipitation correspond in only 55% of cases. Frescott, 1876-1922.
   (Flagstaff, 1898-1922, 60%).

4. D-3 fire records do not go back far enough to give an indication as to existence of a relationship between fire hazard and precipitation.
5. Usually precipitation records are available only for one or two stations, whereas fires occur over an entire Forest.

Reference was made to the rainfall cycles established by Douglass. It was pointed out that these cycles are obtained by averaging the precipitation by 5-year periods. Values for individual years fluctuate over a wide range, and therefore the precipitation for a particular year cannot be predicted. Moreover, the rainfall during the usual fire season, May and June, may not agree with that of the entire calendar year. At Prescott the correlation between May-June and annual precipitation is only 55, and at Flagstaff 60 per cent.

Cox - It is well known that the local occurrence of rainfall is erratic. Rainfall and sunspot cycles are based on averages. We cannot predict the exact year of the maximum or minimum.

Mr. Clapp called attention to the need for caution in referring to our work in forecasting fire conditions in order not to create the impression that the Forest Service is entering the field of the Weather Bureau. Mr. Cox stated that sometimes it might become possible for the Weather Bureau to assign special meteorologists to handle this work, but that this cannot be done immediately because of a lack of funds. Show expressed the opinion that what we are [illegible] is merely to interpret the basic predictions of the Weather Bureau in relation to forest fires. Weidman thought that a trained meteorologist could work advantageously with Gisborne at the Priest River Experiment Station.

Bates - The forester must be enough of a meteorologist to interpret weather forecasts in relation to fire hazard. The theory of sunspot and rainfall cycles is fascinating but in the light of present knowledge these phenomena cannot be employed in the control of fires.

Behavior and Control of Fires.

Relative Humidity in Relation to Behavior and Control of Fires
J. V. Hofmann

I. Instruments used at fires

a. Sling Psychrometer
b. Portable anemometer
c. Sample cans, also used as rain gauge
d. Potentiometer, wire and thermocouples.

II. Records on Different Types of fires

a. Grass
b. Slash
c. Open areas
d. Crown

III. Factors Recorded

a. Meteorological factors
b. Forest type and inflammable materials
c. Behavior of fire
d. Heat and intensity of fire

IV. Conclusions

a. Relative humidity was found to be the one meteorological factor that consistently checked with the behavior of the fire.
b. The existing relative humidity proved to be a reliable index of what the fire could be expected to do.

Mr. Hoffman discussed the use of instruments for the measurement of atmospheric conditions and temperature on active fires. By means of the thermocouples with the potentiometer he has been able to determine the temperatures generated in going fires. This gave him the opportunity to compare fires in grass, slash, open areas, and even crown fires.

In studying the behavior of fire, Hoffman has found that the lighter materials become inflammable earlier in the morning and become non-inflammable sooner at night.

In Hoffman's opinion, relative humidity has been found to be the only one meteorological factor that has consistently checked with the behavior of fires.

Active Influence in the Rate of Spread
S. B. Show

I. Definition

Relation of elapsed time and perimeter of fire.

II. Importance

(a) The only final measure in which to express results of research.
(b) Common denominator of studies and practice.
(c) Easiest term which defines true problem encountered by protective organization.

III. Previous Work

IV. Methods of Determining --

(a) Detailed studies on set fires, under known conditions.
(b) Analysis of going fires.
(c) Analysis of records of fires over a period of years.

V. Form in which rate can best be expressed for principal types and degrees of slope

(a) Maximum rate of spread during period of worst experienced fire weather.
(b) Rate of spread during normal and commonly experienced fire weather.

The rate of spread is best expressed by the increase in the perimeter of the fire as related to elapsed time. In District 5 it has been found necessary to organize to meet the worst conditions of fire as measured by the rate of spread. A tentative conclusion of old studies was that the wind factor is a function of the second power of its velocity. In order to get results obtained by studying the rate of spread of fire into use by the administrative organization, the maximum rate of spread during the period of worst experienced fire weather should be translated into terms of hour control, and from that into terms of organization.

## Behavior and Control of Fires
## Investigations Needed - Pacific Northwest
Wm. B. Osborne, Jr.

The four main factors governing the behavior of fires on any given site are:

1. The moisture condition of the materials on which they are feeding.

2. The volume and intensity of heat developed.

3. Air movements including winds and drafts.

4. Steepness of slope.

Thus far the only investigative work undertaken on this subject has been centered around the first factor which is still far from exhausted. The other three offer very fertile fields for scientific observations and investigation which would be certain to bring out many facts which would be of very material assistance in control work.

In addition to the work done on the moisture conditions of fire fuels Mr. Osborne believes that investigation should be made of air movements under fire conditions. For this purpose he would study the effects of atmospheric conditions and drying in advance of the fire as both are directly and indirectly influenced by topography.

No work has yet been done on the lifting power of drafts created by the fire to determine the extent on which embers may be carried forward.

## Behavior and Control of Fires

### Investigations needed from Standpoint of District 1

Howard R. Flint

Further information on the behavior of forest fires in District 1 is desirable, but the need is far less pressing than the need of forecasts of approaching fire danger or probable lightning storms.

The forecast of fire danger is a measure leading to preparation which will tend to prevent:

1. The occurrence of fires.
2. Their spread to Class C size.

A study of fire behavior will necessarily deal chiefly with fires that have reached Class C size.

Such a study will be useful in:

1. Checking, by a study of individual fires, the correctness of a forecast which said, for example: "Fire danger will be high on August 1 to 3, inclusive."

2. Determining conditions under which back-firing will probably be successful and safe.

3. Securing a better understanding of the intensity of fire danger under varying conditions of fuel and weather.

Information concerning the velocity scope and duration of local winds induced by large fires might be of considerable value in handling such fires.

Mr. Flint: believes that the studying of weather offers the best possibilities for forecasting, but that a certain amount of information can be secured from the study of active fires.

## Behavior and Control of Fires
## Investigations needed from Standpoint of District 5
E. I. Kotok

1. Study differences of behavior, of rate of spread in different types and character of cover; for example, yellow pine, mixed conifer, brush land, fir, redwood, etc.

2. Study of controlling meteorological factors in the rate of spread - for example, relative humidity, wind, inflammability, etc.

3. Actual field study by adequately trained Research men on going fires to check standard methods of control under different conditions.

4. Test present methods of control and suppression technique for given relative rates of spread.

   (a) How close can you work to fires under various conditions?
   (b) What types of line can check fires under different rates of spread?
   (c) Relation of rate of spread and line construction.

Kotok showed how the statistical information in California had been placed upon maps of individual forests. This showed the starting point of fires; intensity and extent of areas burned; and brought out the relation of incendiarism to fires, showing thereby the spirit of the entire incendiary campaign. Maps also showed the visibility from lookouts, and blind areas, and maps showed how to control dangerous areas which were under too slow control.

McLaren suggested as a possible field of research the formation and action of gases generated by going fires. He had noted suffocating gases 20 minutes in advance of the front of an approaching crown fire. Such gases may cause fire to jump ahead of the point where it is actually burning in the timber.

Osborne recalled that the gases killed people in root cellars during the Hinckley fire.

5. Development of Instruments - M. E. Dunlap

At the request of the Priest River Experiment Station the Laboratory undertook the determination of the response of various classes of material to changes in humidity under controlled conditions. This led to the development of equipment at the Laboratory by which the material under investigation, in this case moss, duff, and twigs could be subjected to different degrees of humidity, other conditions being eliminated or kept constant. In this way the rate and change of moisture content of the various materials was determined for different humidities.

Another problem put up to the Laboratory was the development of an instrument for measuring the moisture content of duff in place. For this purpose an instrument should be capable: (1) of showing the moisture content of the fuel in question, that is to say, the combined effect of humidity, soil moisture, and free water; (2) of showing the moisture content from 0 to the saturation capacity of the material; (3) of recording the changes rapidly as they take place; (4) sensitive changes as small as one per cent; (5) durable; (6) fool proof; (7) cheap; (8) easily calibrated. Such an instrument has been devised within limits based on the principle of the lateral expansion of hygroscopic materials.

At first a compression instrument was devised using compression wood as the element. This was not satisfactory owing to the size of the element necessary and its consequent slow response to changes. A tension instrument in which rattan was used as the element was then devised which has proved fairly satisfactory. Rattan expands longitudinally, is cheap, readily obtainable in almost any desired size, shape, and length, and fairly constant in its response to changes. The instrument as perfected consists of a strand of rattan about 12 inches long encased in a perforated tube and connected with a gage reading to 1/1000 of an inch. This instrument when inserted in the duff reaches equilibrium in about 6 to 8 ~~inches~~ hours and thereafter responds readily to changes in the moisture content of the duff and could if desired be calibrated to read directly on moisture content. Its limitation is that it reaches its capacity before the saturation point of the duff is reached and hence does not indicate the higher moisture contents. It does, however, give an accurate record of the lower moisture content in which we are chiefly interested.

As to the practicability Gisborne states that some difficulty was experienced in calibrating only two of the four instruments manufactured being usable for this reason. This difficulty, however, it is believed can be overcome. One of the two instruments in use broke, but the other was found to be accurate within two per cent after two months use. The cost of the four instruments manufactured to date was $39 each.

Suggestions offered as to possible new types of instruments for this purpose include:

1. An electric hygrometer based on the conductivity of hygroscopic material. Such an instrument could be adapted to determine moisture content in duff and above ground and made to approximate different classes of material. Such an instrument or instruments could be so connected up or to be used in the field or read at some central station.

2. (a) A wooden shell mercury type duff hygrometer registering the expansions and contractions of the wooden shell of the mercury bulb as effected by changes in the moisture content.

(b) A modification of the present instrument in the interest of reduced cost in which the tension gage would be replaced by a mercury column which could be read on a scale above the duff.

3. A rotating catgut hygrometer based on the principle that catgut tends to twist more or less as its moisture content changes. Such an instrument, however, would not be suitable for field use.

4. A dew point indicator. This, however, would be somewhat complicated and requires a skilled observer trained in its use.

5. A weighing device by which sections of duff or other material could be weighed in place.

6. Wooden block that could be removed and weighed at intervals. This, however, is not thought to be practical since a block of wood, owing to its volume would be too slow to respond to changes.

Summary

Any instrument to show the moisture content of forest fire fuels should be influenced by the same forces which act upon the material being measured. During the past season a successful duff hygrometer was used in the vicinity of the Priest River Experiment Station. This device can be cheapened and greatly improved. There are still other devices that offer possibilities and should be considered. The possibilities of passing a current through a protected rattan fiber and measuring its resistance or conductivity. These properties vary with the moisture content. The central station reading type offers interesting possibilities. Mercury bulbs offer a simple and cheap method of measuring moisture contents. The rotating hygrometer composed of catgut or a similar material might be made use of. For very accurate measurements a dew point instrument would be of value. This would only be practical for a portable instrument for use in research work.

Where moisture contents above 50% are desirable some device for weighing the duff seems to be the only solution.

The recent developments indicate a profitable use of the duff hygrometer and there are a number of possibilities worth careful study and consideration.

Fire Damage - Fire Damage in Appalachian Hardwood Forests
E. F. McCarthy

The study of fire damage in hardwood forests has been under way for two years at the Southern Appalachian Forest Experiment Station. A large variety of types and sites involved.

Two methods were used.

1. Strip surveys - the dead, injured and uninjured larger trees are calipered. Injury to reproduction determined by sample plots.

   1. Relation to diameter classes definite though not directly proportional. Damage increases proportionately faster for each inch decrease in diameter below 5 inches than above 5 inches.

   2. Relative damage to hardwoods and softwoods.

      Even lightest fires do some damage to hardwoods. Hardwoods are more often killed outright by basal injury than softwoods. There is no great difference in the relative damage to different hardwood species. Thicker barked species such as chestnut oak somewhat more resistant than thin barked species, such as yellow poplar.

      Softwoods are not often scarred at the base except in the case of white pine. Spruce is usually killed outright. Softwoods are more often killed by crown injury than hardwoods. The continuing mortality is higher for softwoods than for hardwoods.

   3. Influence of composition.

      Hardwoods usually sprout after fire injury. Some species have seed capable of remaining viable in the duff. Sometimes true of yellow poplar, usually of locust, and probably of scrub pine, shortleaf pine and sumach.

      Deterioration of the forest results from changes in composition due to killing better species while poorer hardwoods sprout.

   4. The growth rate of seedlings and sprouts on open burned areas usually higher than in cut-over areas, with partial cover.

   5. Unburned adjoining areas.

II. Permanent sample plots, where strip surveys not applicable; these were established a year ago. Four plots comprising 8 acres.

   1. To determine continuing mortality, especially in softwoods.

   2. To study rate of healing of wounds, and the amount of insect and fungous injury while the wound is exposed.

   3. To find the loss in stocking and yield. Stands are thinned out and composition changed for the worse. Knowledge of original stand is necessary. Yield tables are needed.

   4. To determine the influence of cull stands on reproduction and rate of growth.

III. Methods of estimating damage.

1. Method now in use based on expectation value. Classification of stand as to degree of maturity is necessary. Replacement value used for young stands.

2. Time of appraisal. Damage cannot be determined immediately after a fire. At least one season must elapse. Errors due to continuing mortality is greatest in softwood stands.

Discussion

Tiemann: Does frequency of recovery of hardwoods apply to oaks?
Answer: Generally, yes.

Marsh: Is the object a record of actual physical damage to the forest or for use in legal procedure?
Answer: To determine actual damage to the forest.

Forbes: What is the basis for the belief that shortleaf seed remains viable in the duff?

Answer: Seedlings found immediately after fires where source of seed apparently could not have been surviving seed trees. It is difficult to distinguish the different species of pine seedlings when they are young.

Dana: Has damage to soil been considered?

Answer: The replacement of white oak by laurel on burns may be due to site deterioration.

Munns: There has been considerable soil damage but it is rather obscure. Future investigations should reveal its extent.

Fire Damage in Southern Pine
Willard R. Hine

Fire studies at the Southern Forest Experiment Station have been confined almost altogether to investigations on permanent sample plots.

Projects so far established include:

1. Damage from slash fires to:

a. Trees left in logging
b. Site

2. Damage from other fires to:

a. Reproduction
b. Grazing
c. Second growth

1-a. The damage to trees left in logging by a single fire in slash:

Seven plots, ranging from 5.6 to 10.8 acres, previously laid out for another study, were included. 100 per cent tally of all trees 4" d.b.h. and over on all plots, by species and one inch diameter classes and classified as living or dead. 100 per cent tally of all trees down to one inch d.b.h. as above on one plot. Live trees located in position on maps of plots.

Future studies to include loss in numbers and growth, entrance of decay, and effect on seed production.

1-b. The damage to site of a single fire burning through slash:

Same area as in 1-a.

81 5x10 foot quadrats mechanically spaced and covering .27 of one per cent of area. Quadrats mapped. Seedlings marked on ground with wire pins.

Quadrats observed seasonally and mapped annually.

2a. Effect of repeated annual fires on the establishment and survival of seedlings on areas cut over for a period of years.

Roberts Plots (Urania, La.)

Two 1/4 acre plots, laid out in a stand of longleaf seedlings two years old. One plot burned annually each year in winter and one protected. Seedlings tallied by height classes.

After nine years individual tree records started on 200 seedlings in each area. Seedlings tagged to follow a disease in longleaf seedlings.

Florida Plots

Three and one-half acre plots laid out; one each in area burned annually, in area burned at intervals of two or three years and in area unburned. 26 quadrats in each plot mechanically distributed and studied as in 4.

Quadrats remapped following next heavy seed fall.

McNeill Grazing Pasture (Mississippi)

Periodic count of seedlings by height classes on narrow strips covering 1 per cent of area in grazing study. (See below).

2-b. Effect of annual burning on the carrying capacity of the range for cattle.

Two 160-acre pastures, one burned annually and one kept rough. Each grazed at the rate of one head of cattle to ten acres. Cattle weighed at intervals of two to four weeks. Studies of changes in vegetation, weight of cattle, etc., carried on by cooperating agencies.

2-c. Effect of repeated annual fires-burning at each of the four seasons of the year on young stands of pine.

Stands selected are pure, even-aged, and when possible on Site II and in cut-over areas. Stands selected cover the range of height and diameter from seedlings a few inches high to trees 12 inches in diameter.

| | | | | |
|---|---|---|---|---|
| Youngest stand - trees from | 1 | to | 10 | years |
| Middle class - " " | 10 | " | 20 | " |
| Oldest class - " " | 20 | " | 30 | " |

Five plots varying from 1/6 to 1/4 acre in size laid out in each stand. One plot burned annually at each of the four seasons of the year. One plot retained as check. Isolation strip of 7 feet or more around each plot treated in manner similar to plot.

Numbers painted on trees. D.b.h. of all trees over one inch measured with diameter tape. Trees over one inch tallied by height classes. 20 per cent of heights of larger trees measured with Faustmann hypsometer. 25 per cent of smaller trees measured for height and length of crown with measuring pole. Trees classified according to four crown classes. Special record of seedlings on one series of plots secured on strips, 11 x 32 feet, through plots.

Description made of each area at time of establishment of plots. Similar record to be made each year. This record includes notes on underbrush, ground cover, litter and soil. Measurement of litter in one plot secured from a number of litter stakes driven level with ground. Scars on trees measured for height and width.

Special effort made in one set of plots to secure uniformity by altering conditions through cutting.

To determine the rate of removal of litter ten stakes were driven with the tops flush with the ground, the thickness of the litter being measured periodically over these stakes.

## Discussion

Bates: Why not consider trees below 4 inches in d.b.h.?

Answer: The original purpose of the plots was for a management study. The plots were later taken over as fire damage plots. The original records were not taken for trees below 4 inches.

Carter: Are the plots fenced against razorbacks?

Answer: Part of the plots are fenced.

Zon: There should be a few definite objectives in the study of fire damage to determine:

1. The measure of fire damage. Plantations of the proper age compared with similar plots burned over might be used.

2. The basis for an estimate of damage of different character.

3. The relation of fire damage to types.

4. A uniform method of calculating damage statistics. Fire insurance companies could use these as a basis for offering forest fire insurance.

Pearson: How could the history of stands suggested by Zon be determined?

Show: The record is carried in fire scars.

Behre: Zones of rings of different widths indicate history.

McCarthy: The history of natural stands is very uncertain. It is difficult to get comparable stands. Southern Appalachian stands are not even aged.

Forbes: Fire damage in southern pine is often obscure. We must go into extreme detail to obtain convincing evidence. Munns showed us last fall that our damage was much heavier than we had suspected.

# Fire Damage in the California Pine Region

By E. I. Kotok

## I. Nature of Problem in California Pine Region

Fires in California are not usually as destructive as in Idaho or the Lake States. Damage is often obscure. Population favors burning.

### A. Fires in the Virgin Forest

#### a. Direct Physical Losses in Mature Timber

1. Injury from fire scars.
2. Burning down of scarred trees. Averages 930 bd. ft. per acre. Is independent of intensity of fire.
3. Loss of wood. Mill scale studies by Berry and Munger show that 17 per cent of the cull in pine is directly due to fire injury.
4. Direct heat killing. There are occasional flare-ups of local character causing heat killing. Crown fires in virgin forest are rare.

#### b. Indirect Losses

1. Crown injury and reduction in growth rate. Proportional to crown destroyed.
2. Insect injury and fungi. Meinecke and Boyce's studies show a decrease in yield.
3. Damage to young growth. Varies from reduction in numbers to complete destruction.
4. Process of attrition. Encroachment of brush fields at expense of timber area.
5. Indirect financial losses due to reduction in grade and increase in logging costs. The best quality material affected by fire scars and burning down.

### B. Fire in Second-growth Stands

1. Crown fires frequently occur.
2. Effect of repeated fires.

### C. Fire Damage on Cut-over Areas

May complete devastation by destroying seedlings and source of further seed crops.

D. Fire in Brush Fields

1. Site deterioration; the only indication is changes in plant composition.
2. Reclamation of brush fields. Dependent entirely on fire control.

E. Light or Controlled Burning

Stockmen usually prefer complete removal of cover to increase forage rather than light burning.

F. Damage to Watersheds and Other Resources

Particularly important in Southern California. Little progress made in actual determination effect on water. Does seriously affect erosion. Studies needed over long period. The people are convinced of the value of brush cover.

II. Work Done

1. 44,235 acres examined intensively by the strip method 1 or 2 years after fire.
2. Following permanent sample plots through a series of years.
3. Objectives: To check damage data secured by field officers for fire reports. Determination of extent, character and best way of expressing damage. These data criterion of success or failure of fire protection - the basis of sound forest management and development of a land policy.

III. Methods

A. Permanent Sample Plots with Control Plots (Includes Studies of Six Plots)

1. Data secured of reaction of individual trees to fire, also reaction of stands.
2. Effect of single and repeated fires.
3. Inter-relation of damage factors.
4. Obscure and continuing form of fire damage, i. e., rate growth, insects.

B. Intensive Studies of Damage by Principal Types on Past Fires, 44,235 acres

1. Strip method used.
2. Data on direct and immediate damage on stand secured.

C. Water Relation and Damage to Forest Cover

1. Observational method used.

## IV. Tentative Conclusions

A. Indirect damage and subsequent losses may be actually greater than direct and immediate loss to mature timber, second growth and reproduction.

B. Ascertaining amount of direct damage to mature timber and reproduction can be made with fair degree of accuracy if sufficient time and care are taken. This work can be done by our average Ranger.

C. Ascertaining amount and extent of indirect damage - a long-time process, requiring skilled research personnel.

D. For the present it will be satisfactory if administrative personnel secure and record actual direct physical losses of mature second growth and reproduction. Useless to attempt to have them give estimates of intangible or indirect losses.

E. No involved method for calculating values feasible to adopt, and to put into use by field officers. If physical inventory is made with fair degree of accuracy and records maintained, values as they shift can be applied.

## V. Investigations Needed

A. Water relation and damage to forest cover.

B. Effect of single and repeated fires and insect infestations.

C. Site deterioration.

D. Changes in composition of stands.

E. Possible uses of fires in regeneration.

F. Liability table, establishing average losses for given types.

G. Possible uses of fire for protection - economic question of proper balance between damage, costs and desirability of objects to be attained.

### Discussion

McCarthy: Can damage be accurately estimated immediately after fire in California?

Show: No, and I doubt if it can anywhere else.

Weidman: Three sample plots for the study of fire damage have been followed for six years in District 6.

1st year a high per cent of trees seemed dead due to soot on foliage and limbs.
2nd year fewer trees seemed dead.
3rd year some recovery apparent. Insects begin to select trees which might otherwise recover.
4th year less change - conditions in the stand became more stable.

## Preliminary Report of the Mather Field Committee on the Administrative Methods of Evaluation of Fire Damage

S. B. Show

Many foresters have endeavored to find a satisfactory way of evaluating fire damage.

I. What constitutes physical damage?

Present data are inadequate and inaccurate.

Damage should be expressed in volume and area of merchantable timber, (assuming a size limit for merchantability for each region), age, sizes, and area of young growth, and area of protection forest.

In mature stands there are two sets of conditions:

1. Most of the stand is killed outright. An ordinary cruise gives the damage.

2. Damage is partial, delayed mortality and induced losses continue for several years. An immediate estimate of damage is here useless. Intensive local studies are necessary to determine the best methods to be used.

II. Valuation of damage.

1. Merchantable timber. The present system is chaotic. Regional stumpage rates as determined by prices on going sales. The Committee did not agree as to whether a region should be further subdivided by accessibility zones.

2. Immature timber.

Two most used present methods, expectation and replacement values, give wide discrepancies.

No actual value now placed on young growth.

Summary of suggestions

1. The rate of interest used in calculations should be based on the earning capacity of the soil as indicated in the report of the Committee of the Society of American Foresters on rate of interest.

2. Recognize broad regional zones in which prices on going sales are used as a basis for stumpage values.

3. From data available determine whether a fair forecast of future stumpage prices can be made.

4. Improve methods of determining and recording physical fire damage.

Discussion

Kelley: Is discount rate to be used largely as a discount rate?

Show: With final yield and value as a basis the value at any intermediate period could be determined by discounting graphically on semi-logarithmic paper.

Carter: Will the scheme be used in statistical computations by the Forest Service?

Greeley: The primary object is for our own information as a business or administrative record. In case of court procedure these records might be used as a starting point.

Show: The Committee emphasized the importance as a business record.

Greeley: Is the going price of stumpage a sound assumption as a basis?

Show: All stumpage curves are now rising rapidly. Future predictions are very difficult. Donald Bruce has suggested the work of Raymond Pearl of Johns Hopkins University in predicting future population as a possible parallel.

Kittredge: The use of population curves to predict stumpage rates seems questionable. Population changes follow biological laws while stumpage prices follow economic laws. The trend of commodity prices would seem to be a better index.

Dana: (Reads the report of the Joint Committee of the Society of American Foresters and the Association of State Foresters.)

Carter: Did the Committee consider as one of the economic factors the interest of the Society in the destruction of unmerchantable protection forests as an existing entity?

Show: The Committee recognized that there is a loss to society in the destruction of such forests but saw no way of measuring it.

Carter: How did the Committee consider cases where the stand per acre is reduced to the point where the remainder is a loss because it cannot be logged at a profit?

Kotok: An effort has been made to express such losses in the California pine region. For example, with an average stand of 28000 bd. ft. per acre in the better sites a reduction of

| | | | |
|---|---|---|---|
| 500 bd. ft. per acre | reduced the stumpage value | 4¢ | per M. |
| 1000 | " | 8½¢ | " |
| 1500 | " | 13¢ | " |
| 2000 | " | 18¢ | " |

On poorer sites the reduction would be proportional.

Shepard: What was the objection to using replacement value?

Show: Where destruction is complete and there is no possibility of natural regeneration for a long period, this is the only basis that can be used.

Kittredge: What would be the procedure in case of species with no present stumpage value?

Show. An arbitrary minimum would probably have to be set.

Flint: Of just what value is an expression of damage in terms of money?

Greeley: An index of the efficiency of our protection work. A business check of costs plus damage against values at stake. A future basis for insurance rates.

Flint: To indicate the efficiency of protection in work great complexity and refinement in methods of determining damage seem unjustified. Calculations involving compound interest are of doubtful value.

Shepard: Where young growth has no present value as indicated by computing the expectation value, the cost of replacement should be used and charged as a current cost to depreciation of the producing plant.

Carter: Could an arbitrary value be set for destroyed watershed forests?

Show: It is difficult to set a money value.

Greeley: I believe an arbitrary value could be set. In one case the court held that the act of setting aside an area as a National Forest and protecting it constituted evidence of some value but the exact value was not fixed.

Osborne: We should keep a record of actual material destroyed. The use of present stumpage prices as a basis for calculating expectation values defeats our efforts at protection by showing apparently low rates.

Show: A reasonably good prediction of future stumpage values could probably be made from data now available in Washington.

Kotok: The expectation value could be worked out on the basis of present prices without carrying costs since such costs go on regardless of whether the stand is replaced or not.

Greeley: The Committee should consider the suggestions made and modify its report if possible before the end of the Conference. If we are going to attempt the prediction of future stumpage prices, what is the best method of doing it?

Kelley: Could the Committee consider further what methods the research organization should follow in determining actual physical damage?

## FINAL REPORT OF MATHER FIELD COMMITTEE ON FIRE DAMAGE AS PRESENTED AND DISCUSSED AT MADISON MEETING

As in the original report the committee emphasized as strongly as possible that valuation of damage, without careful determination of physical losses, was impossible. The report was and is therefore divided into two parts.

### Section I - Physical Damage Data

1. Present conditions of collecting (i. e., guessing) damage both to timber and reproduction are unsatisfactory and the data are inaccurate and inadequate. This is true in parts of the National Forests, and is generally true outside the forests and in regions where the National Forests are unimportant in area.

2. Physical damage data should be secured on the basis of type and site, and should be recorded for permanent use expressed as volume of merchantable timber by species destroyed; acres of timber destroyed; age (or size), species, and acreage of reproduction destroyed separately when new reproduction will and will not follow naturally; acreage of protection forest and (or) protection brush destroyed; acreage of barren land, grassland, etc., burned over.

3. In mature (or merchantable) stands two general cases must be recognized, and it is proposed to adopt the following:

a. When most of the stand is killed outright as typically in the western white pine, a cruise either immediately after the fire or in the fall gives satisfactory results. The standard of cruising used should be that adopted for intensive timber surveys in the region concerned. Sample strips should generally be used in preference to sample plots.

b. Where fires result in only partial killing, as typically in the western yellow pine region, and where delayed mortality and secondary losses induced by fire continue for several years, an immediate cruise is useless. In practice it will be necessary to estimate the direct damage in the late fall after the fire, recording obviously dead trees and separately seriously injured trees the ultimate recovery of which is doubtful. Intensive local studies are necessary to determine regional working figures showing the percentage of doubtful trees that succumb. Preliminary investigations indicate that this varies from 1/4 to 1/2. Additional local studies are needed to determine by regions the extent of secondary losses such as loss from fire scars, reduced growth, insect losses, etc.

c. The method used in estimating should be specified, and more emphasis should be placed on careful cruises than in the past.

4. Loss of advance reproduction under mature timber should be clearly distinguished from destruction of reproduction, as on second burns in western white pine and brush fields in California, where natural reproduction will not follow promptly. Estimates of degree of stocking and of area burned should be made with as much care and uniformity as in mature timber.

5. In case of destruction of protection forest or of protection brush (as in California) a determination of areas and of an approximation of age only are needed.

6. At present damage to soil can be expressed only in terms of depth of litter or humus destroyed.

7. Figures used or made public should clearly distinguish the following classes of areas, both in terms of areas burned and of damage.

a. Merchantable timber - including reproduction under timber. True woodland should properly come under this category.

b. Areas of reproduction, where a new stand will not follow naturally and promptly. This might well include cut-over lands, though it may prove desirable to recognize these as a separate group.

c. Protection forest and protection brush.

d. Practically worthless areas, principally barren land.

e. Perhaps grass range.

Present practice of lumping all these together in much publicity material is exceedingly unsatisfactory.

8. Forms for permanently recording physical damage data as proposed by District 1 are recommended for use in regions where clean burns are the rule. Some modification may be needed for such regions as western yellow pine, where partial destruction of merchantable timber is the rule. District 5 will be glad to undertake the preparation of such forms.

## Section II - Evaluating Damage

1. For evaluating damage to timber of merchantable size regional stumpage rates should be established. Within each region it may be desirable to recognize two or three accessibility zones, if such exist, with differences measured by intrinsic cost of transportation and logging. Stumpage rates by species for each region should be recommended after study by the District Foresters, and correlated as between districts or regions by the Forester. In determining rates for the so-called inferior species, great care should be used since existing stumpage values do not usually measure intrinsic differences in value between species. For species of recognized value probably average or average maximum present sale values might well be used. For inferior species, a study should be made of ratios for example between superior and inferior species in older regions as the Northeast and Lake States. The data on stumpage prices available in the Forester's office should furnish a basis for sound judgment in deciding regional rates.

2. Present methods of evaluating damage to immature timber, especially where new reproduction will not follow naturally, are chaotic and unsatisfactory. Two principal methods are in use: (a) expectation value, at maturity, discounted at an assumed interest rate to the age of stand destroyed, and (b) replacement value, calculated from cost of planting, plus compound interest at an assumed interest rate and stated annual charges to age of stand destroyed. The two methods applied to the same stand often give widely varying values due to the universal use of an assumed interest rate. This naturally results in difficulties in court cases, failure to place damage to reproduction in its proper place in the scheme of fire protection and lack of conviction in putting the case for protection of such resources before the public. The most urgent need for reasonably accurate evaluation of damage is as a business record for our own information and use.

3. In time actual market values will become established for reproduction, and these will be a composite of expectation and replacement values. At such a time the problem of valuing damage to reproduction will solve itself.

4. In the meantime, recognizing the essential soundness of expectation value and the legitimacy of planting cost as a starting point it is proposed to adopt the following plan:

a. Assemble for each region the best available data on yields which will generally be more than we are likely to think we have. An attempt at hairsplitting accuracy is not necessary. Similarly, rotations can be set for principal species or sites with sufficient accuracy from existing data. If in forest working plans it is customary to recognize site differences similar distinctions should be made in the yield figures.

b. Present sumptage values are an exceedingly inadequate expression of future rates, because values are rising rapidly in all parts of the country. There are two possibilities which none of the committee members has been able to investigate thoroughly. First, a mathematical law of population growth has been developed by Dr. Raymond Pearl of Johns Hopkins, which possibly may apply to stumpage price trends. This is perhaps doubtful since population growth follows biologic law and stumpage prices follow economic laws. Probably a better index would be the rate of change of commodity prices over a long period. Preliminary investigation of this showed that for the past four centuries prices have increased at an average compounded rate of about 1/2 of 1 per cent per year.

The use of some such method of forecasting future stumpage values will remove much, though not all, of the speculation, and will give the undoubted increase a proper place in damage calculations. It will at least be a step ahead of present haphazard practice. To decide on the best basis for prediction is a project that the present committee cannot answer. Analysis of all available stumpage price data in Washington should be undertaken to determine if possible the law of stumpage price changes. The committee has undertaken the securing of comprehensive data from Europe as a basis of study.

c. The present value of a one-year-old stand of reproduction can only be expressed as either (1) cost of planting (which should be a regional rate), in case natural reproduction will not follow the fire, or (2) cost of protection and administration during the regeneration period where natural reproduction will follow.

The final value at the end of the rotation is the estimated yield times estimated stumpage rate, determined as outlined above. Tables might well be constructed for each region showing dollar values per acre at maturity, instead of in feet per acre and stumpage rate in dollars per M. District 6 has prepared tables of this type.

The rate of interest actually earned by any stand is not a matter of assumption but must be figured back from final value at maturity to initial cost. Stands on excellent sites and on short rotations will earn 7 or 8 per cent compounded, while some stands on poor sites with long rotations may earn only a fraction of 1 per cent, and by the plan outlined the true earning power will be expressed at any age between one year and maturity but not at one year. The basic idea of recognizing earning power of different forest lands, instead of assuming a fixed rate of interest, has recently been accepted by the committee of the Society on the rate of interest in forestry.

As a mechanical aid in determining intermediate values compound interest curves plotted on semilogarithmic paper appear as straight lines and interpolations are easily made.

5. Forms of damage other than those of a purely physical nature were recognized in the committee, but no plan is proposed to evaluate them. The principal forms of this nature are the social loss of forest producing area, the loss due to disruption of management plans of a forest property, partial destruction of a stand so that it is removed from the exploitable class, and increased logging costs due to decreased stand density.

6. In expressing money value of damage to protection forests or protection brush no place can be offered other than arbitrary values per acre, which should be harmonized by the Forester between regions.

7. In case of species of present negative stumpage values, arbitrary values may in some cases be necessary.

8. The committee believes this plan to be feasible and desirable, provided, however, that accurate data on physical damage are first necessary.

9. The proposed plan would, before inauguration, involve the following specific jobs, which might be handled as suggested below:

a. Regional stumpage prices for species, by accessibility zones if desirable. Best handled by Forest Management in the districts harmonized by the Forester.

b. Estimated yields. Use data already assembled by Research and by Forest Management in preparation of working plans.

c. Future stumpage rates. Analysis of data on stumpage prices by qualified man in Washington, or accept same average rate of increase as for general commodity prices.

d. Forms for recording physical damage data. Use D-1 forms as basis, modified where needed for regions with partial destruction of mature stands.

e. Planting costs. Experience values, harmonized as between regions by the Forester.

f. Values of protection forests and brush. Harmonized between districts by the Forester.

The essential features of the plan are briefly:

1. Much more emphasis than in the past on accurate physical damage data.

2. Establishment of regional and accessibility zone stumpage rates.

3. Recognition of stumpage price increases and available yield data in determining values of stands at maturity.

4. Recognizing cost of securing new stand either artificially or naturally as the starting point of calculations of value of young growth.

5. Computing actual earned rate of interest back from final value of stand to cost of establishment as basis for determining intermediate values for immature timber.

## Analysis of Fire Statistics for California
S. B. Show

### Question 7. - Part 1.

I. Basic Data

Definitions. Source. Essential data to keep.

II. Administrative Problems of Most Urgent Need

1. Define accomplishment in terms of organization.
2. Fundamental relationships.
    (a) Elapsed time.
    (b) Seasonal fluctuations.
    (c) Relation of man power to acreage burned.
3. To check results of different theories and methods of protection and prevention.
4. Determine characteristics of different groups of fires.
5. Determine relative spread and difficulty of control in different cover types.
6. Determine sliding scale relations of prevention, suppression and damage costs.

7. Determine principal critical factors, especially overload and violent changes in weather.
8. Define protection problem in concrete terms for different protection units by occurrence and rate of spread of fires.

III. Methods of Attack on Such Problems

1. Study of individual fires inadequate.
2. Statistical analysis - Use of homogeneous groups offer best chance of solution.
3. Importance of maps, e. g., start of fires and burns.

IV. More Important Results

1. Striking differences in seasonal and geographical distribution of fire from different causes, also in rate of spread.
2. Limits of accomplishment of different intensities of protection.
3. Critical importance of overload and certain climatic conditions.
4. Importance of types in relation to rate of spread and preliminary evaluation.
5. Importance of the damage factor in systematic protection.
6. Methods of statistical analysis can isolate different important factors.
7. Causes and nature of breaks.
8. Determination of relative needs of different units as basis for allocation of funds.

V. Proper Place of Research in Fire Protection Studies

1. Studies of fire protection just as necessary as cutting studies.
2. Analysis of individual fires, etc., an administrative function, but critical examination of fire protection as a whole requires research point of view.
3. Aid in development of economics of fire protection.
4. Develop methods for utilizing accumulated experience, i. e., statistical studies.

## Local Application of Statistical Analysis of Fires for California

E. I. Kotok

1. Conclusions from General Statistical Studies apply to Local Units

(a) Chief difference in mechanics of presentation.
(b) Statistical vs. graphic.

2. Factors which Must be Considered

(a) Risk - intensity and class.
A basis for prevention measures.
A basis for placement of men.

(b) Hazard - extent and character of burned-over area.
A basis for protection.

(c) Effective visibility as a factor of elapsed time.

(d) Travel and hour control.

(e) Communication.

(f) Elapsed time.

(g) Cover.

3. Checking Practice and Isolating Weak Spots in Protection

(a) Area burned over as final test.

(b) Setting up standards of accomplishment and performance.

Individual fire reports are basis of statistical analysis in California. Such information as date, cost, location, area burned, damage, elapsed time, and the essential data. Results should be defined in terms of the organization which will apply the results. In many instances the results show relative differences rather than absolute. The theory of protection rests on the costs of direct suppression and damage. Analysis of statistics isolates causes of overloads which in turn cause breakdowns in times of severe hazard. Complete analysis will bring out the accomplishments of the similar units such as the forest. The results are dependable because they are the summarized experiences of hundreds of men. The analysis of statistics proves the solution to such problems as the conditions under which an increase should be made in the protective force in preparation for overload.

The damage factor becomes more dominant with further study. While the analysis of individual fires is an administrative function, the analysis of masses of fires is a research function.

Analysis of Fire Statistics for Pacific Northwest
Wm. B. Osborne, Jr.

Purpose of statistics

1. As basic part of fire plan of each Forest.

2. As an administrative check on the functioning, performance, and results of individuals and organizations.

3. As an assistance in the determination of allotments between ranger districts, forests, and districts.

4. A resume of the fire history by forests, districts, and the Service.

5. Special studies.

6. Psychological effect on organization.

7. Publicity data.

Methods of analysis

There are many different methods of analysis that may be employed, and different methods must be employed for different purposes. The object is to select the method which will give the clearest and most correct answer to the problem involved. The most common methods are:

1. By means of maps.
2. " " " graphic charts
3. " " " summary tabulation of all essential details of each fire report.
4. " grouping within limits.
5. " totals and percentages.
6. " curves (much poorer than cumulative graphic chart.)
7. " averages.

Averages must be used with great care.

For many analytical purposes they are apt to cover up the very things that should be investigated.

Taken alone, they are often meaningless, misleading or even dangerous.

Hazard and liability for various types and regions have been very clearly brought out by:

1. Graphic maps.
2. Analysis of statistical records.
3. Direct observation.

Special study of elapsed time and damage has never been considered feasible or possible from data here available.

A great deal of attention has been given, however, to an analysis and follow-up of the elapsed time record.

No new records to suggest, although much can and should be done to improve and simplify present records.

In discussing fire statistics in the Northwest, Mr. Osborne indicated that there might be trouble in the collecting of too many statistics thereby laboriously carrying to the central office of the District information which should be known and used by the Supervisor or Ranger on the ground.

## Lightning Fires in California - E. I. Kotok

### I. Nature and Importance of Lightning Fires

1. Bunching in time and space.
2. Inaccessibility.
3. Occurrence in more dangerous fire months.
4. Overload on protection organization.

### II. Classification of Lightning Storms from Standpoint of Foresters

1. Local isolated storms.
2. Regional storms.
3. Peak load storms.

### III. Information Needed concerning Lightning Storms

1. Centers of formation.
2. Direction and regularity of travel.
3. Relation to major climatic factors.
4. Influence of topography and geology.
5. Differences of types of storms.
6. Relation of fires started and character of storm.
7. Precipitation accompanying storms affecting start and spread of lightning fires.

### IV. Work Accomplished in California

1. Three years' record, exceedingly broken, using lookouts as observers.
2. Data secured covered -
   - (a) Origin of storms
   - (b) Path of storms
   - (c) Intensity of storms
   - (d) Fires set
   - (e) Precipitation

V. Preliminary Conclusions

1. Distinct local storms extending over small areas.
2. Regional storms frequently extending over a period of days, apparently a series of overlapping storms.
3. Storm centers do exist.
4. No well-defined storm paths have been discovered, but there is a regional trend in point of time.
5. General storms appear to occur with several types of weather map.
6. Southern Sierras and Southern California have distinct storms of their own.
7. North Coast Ranges and Northern California and Northern Sierras have a distinct set of storms.
8. A series of days of extra high maximum temperatures often precedes a lightning storm, but not always.
9. Relation of vapor pressure and formation of storms not evident.
10. Not possible yet from data secured to predict lightning storms or the direction of their development.

VI. Work for Future

1. More data needed - both in detail and completeness.
2. Investigation of lightning storms should be tied in with other studies of weather and fires.

The lightning storms which interest the forester, as contrasted with the meteorologist, are, of course, those which set fires. The significant features of such storms are their occurrence in the seasons of relatively large fire danger, starting fires at points difficult of access and in numbers which constitute an overload on the protective organization.

Records of lightning fires have been obtained from fire lookouts in District 5 for the last three years, but they have been largely broken and desultory, and only those for the past year have any statistical value. Many of the records are very sketchy, and the proportion useful in drawing conclusions is probably 60 per cent or less - as in District 1. More time will be necessary to get significant results. The needed information falls under the following points:

1. Location of centers of formation.
2. Direction and regularity of travel.
3. Relation to major climatic factors.
4. Influence of topography and geology.
5. Differences of types of storms.
6. Relation between the character of the storm and the fires started.
7. Relations between precipitation which accompanies the storm and the start and spread of lightning fires.

To secure this information lookouts are asked to report upon:

(a) The origin of lightning storms as to time and place.
(b) The time and distance at which the storms passed.
(c) intensity, in bolts of lightning.
(d) fires set.
(e) the approximate amount of precipitation (light, medium, heavy).

From the rather slender records so far obtained the following preliminary conclusions have been drawn:

1. Distinct local storms extend over small areas.
2. Regional storms frequently extend over a period of days, apparently a series of overlapping storms.
3. Storm centers do exist.
4. No well-defined storm paths have been discovered, but there is a regional trend in point of time.
5. General storms appear to occur with several types of weather map.
6. Southern Sierras and Southern California have distinct storms of their own.
7. North Coast Ranges and Northern California and Northern Sierras have a distinct set of storms.
8. A series of days of extra high maximum temperature often precedes a lightning storm, but not always.
9. Relation of vapor pressure and formation of storms not evident.
10. Not possible yet from data secured to predict lightning storms or the direction of their development.

The regional storms are not a single, but a series of disturbances. There is a general directional tendency, usually north to south but sometimes south to north. Such storm series may cover the whole of a "storm area" in a four-day period. Practically all large storms come from the east. A storm warning service which would forecast the peak load storms would be of the greatest value. It would appear possible to convey such warning 4-5 hours before a peak load storm breaks. Then with 3-4 hours before the fires start there would be an elapsed total of seven hours or more in which to organize for suppression. In this connection it is important to note that the Service can organize for a peak load storm far better than for a single fire. In a series of conferences with Weather Bureau officials, the latter were confident that with sufficient data they could forecast large regional storms but not local ones.

To determine the nature and importance of lightning storms as causes of fires, more records are needed and more attention both to detail and completeness. Investigations of lightning storms should be tied in with other studies of weather and fires. The problem is very complex and its most important feature relates to peak load storms which constitute an overload on the protective organization.

In answer to questions by Mr. Cox, Meteorologist, U. S. Weather Bureau, Mr. Kotok reiterated that some storms (general, not local) move from east to west, while some work from one point in both directions and some take a clockwise direction. Mr. Cox characterized the east to west movement as a "very unusual occurrence."

## Analysis of Fire Statistics in the Northern Rocky Mountains

Howard R. Flint

Flint pointed out that the past products of collecting a large amount of information on fires had served a good purpose when detailed analysis of these statistics was undertaken. He agrees with Osborne that the average of statistics from a fire has value only for public relations, and that the biggest lessons are learned from individual fires. Extreme conditions result in the biggest losses. District 1 records are being kept in a manner very similar to that used in Districts 5 and 6.

A committee was named consisting of Munns, Chairman, McLaren, Kotok, Osborne, and Flint, to submit specific suggestions and reasons for desirable changes in the fire report and fire forms.

Kelley - pointed out how little the average Supervisor knows about his detailed causes and losses by causes. Work cannot be handled efficiently without such knowledge.

From Washington office standpoint it appears that use of statistics must be largely on basis of averages.

Present individual fire report is the nearest possible representative or compromise of the concensus of opinion of the fire and operation chief of the various districts.

Zon - Practically no fire statistics available for Michigan and Wisconsin. Fire statistics being published at present are very defective. Too general. Need for more detailed statistics felt in Lake States so that points which should be emphasized are covered.

Mr. Conzet, when asked how fire reports can be improved for fires on private lands, stated that all rangers do not use same judgment and units of measure because they do not understand the resultant use.

Mr. Forbes - agrees with Mr. Conzet that if you want better fire statistics on private lands you need better rangers. Urge and explain adoption of uniform methods of appraising and reporting fires. Not much field for research to help get the statistics, but research wants them to use.

Tillotson - States are paying more attention to uniform forms. Committee of State Foresters been appointed to bring this about.

Federal Service cannot dictate to state foresters what is wanted. Request should be made, but must know just what is wanted before we can ask for it.

Zon - Research should get into the game to encourage collection of statistics if it wants them.

Dana - Society of American Foresters - Association of State Foresters have submitted joint report showing what information should be obtained by fire reports. Does not believe this report will solve the problem, however. Believes that research should bring pressure to bear on state foresters showing need for and value of these reports.

Carter - Distinct limits to which the Service should go in bringing pressure to bear on state foresters by holding out Weeks Law money. Should use our education function first, before we use the "big stick."

Branch of Forest Management, however, would be very glad to cooperate with Research in requesting changes desired in state foresters' data.

## Lightning Fires in Northern Rocky Mountains

H. G. Gisborne

The fact has been well emphasized that we need warnings or forecasts of lightning storms several hours in advance of the occurrence of the fires that probably will result. During the past fire season District 1 experienced seven peaks of lightning storm occurrence. Five out of these seven peaks were forecast several hours in advance by the Weather Bureau. The warnings were there; did we use them? During the past summer, the lookouts saw the storms that caused 318 fire reports in northern Idaho over an hour before they saw any fires to report. They saw 213 storms over 6 hours before they saw the resulting fires; they saw 135 storms over 12 hours before the fires appeared. The warnings were there; again, did we use them? The answer is no, because we did not know the warnings were there until our lightning study brought out the fact. This is presented in this way merely to show one possible result to be expected from fire studies. We have been worrying about obtaining warnings of lightning storms and fires and it appears that the warnings were already available - if we had only known it.

During the fire season of 1922 we had 149 lookouts and Rangers who reported on all the lightning storms that they saw. During 1923 we had 162 stations which reported. At the close of the 1922 season we compiled our data and produced several tentative conclusions.

Within the past two weeks I have completed the compilation of the 1923 reports. The new results substantiate some of the conclusions obtained in 1922 and reverse some of them; a brief comparison of the results for both years may help to show what can be expected from the study as we are conducting it.

We wondered if individual storms could be tracked for long distances across the country and if they followed certain paths consistently. The answer for both questions from both years is no. In only a very few cases have our reports shown the apparent movement of a single storm for distances of over 50 to 75 miles. In only a few localities have the storms been found to follow regular paths which differ from the prevailing wind direction.

We wondered if storms and resulting fires could be forecast. The answer appears to be yes - with qualifications. During July and August, 1922, our region experienced seven peaks of lightning storm occurrence. Two of these peaks were forecast by the Weather Bureau. During 1923 there were seven peaks and five were forecast. In 1922 we had no way of knowing the elapsed time between sighting the storm and discovering a resultant fire. During 1923, for the seven Idaho Forests, 3 per cent of the fires reported by lookouts were sighted within less than an hour after the appearance of the storm; 97 per cent of the lightning fires were discovered over an hour after the storm was first seen, thus providing a one-hour or longer warning for 97 per cent of the fires. Furthermore, 65 per cent of the fires did not appear until more than 6 hours after the storm was first seen; 41 per cent were 12 hours or more behind the storm; 15 per cent were over 18 hours later. Two methods of forecasting seem usable if these conditions continue. The Weather Bureau can be depended on to give us warnings at 8 or 9 o'clock each morning, and the lookouts can notify headquarters of the appearance and character of storms as soon as they appear. Difficulties are present in both methods, of course.

If the Weather Bureau forecasts lightning storms during the day and if only two or three stations report the occurrence of storms the forecast is correct, but useless. In District 1, during July and August, 1923, there was only one day out of the 62 when not a single station reported a lightning storm. Hence forecasts of storms for every day of July and August would have been technically correct 98 per cent of the days. What we want are forecasts which are correct and also usable. We want forecasts of these peaks.

Confining the discussion to northern Idaho alone (the region of most lightning fires and the region for which we received special forecasts during the past summer) the following facts appear:

If less than 25 stations reporting storms on any one day means no special attention warranted, then there were 15 forecasts of lightning storms received which were technically correct, but not worth attention.

If from 26 to 40 stations reporting storms means some attention warranted, then 2 forecasts were correct and usable.

If 41 or more stations reporting storms means a possible overload of fires, then seven forecasts were correct.

But there was one day when over 41 stations reported storms and none had been forecast; and there were 2 days when from 26 to 40 stations reported storms and none had been forecast.

Hence the Weather Bureau hit the mark in forecasting occurrence at over 40 stations 7 times out of 8, or 85 per cent dependability. And for all cases deserving attention they forecast 9 days out of 12, or 75 per cent dependability.

It is evident that if we had acted on all their forecasts of lightning storms we would have been prepared 15 times when it was not necessary, 9 times when it was necessary, and we would have failed to prepare 3 times when we should have. Rather dependable warnings when considered in this way; but it would be desirable to know the probable extent of the storms more accurately than can be forecast at present. That is something to be worked for.

Now, considering the lookouts as an agency for providing warnings: as has been stated, a six-hour or better warning could have been given for 65 per cent of the lightning fires discovered by the Idaho lookouts, or a one-hour or better warning for 97 per cent of their lightning fires. But these Idaho lookouts reported approximately 987 storms, only 250 of which resulted in fires. If each report of a storm had been taken as a warning to prepare for fires, about 3 out of 4 warnings would have been wrong and only one correct. Fortunately, it appears that there are certain characteristics of lightning storms which can be used to estimate whether the storm is dangerous or comparatively non-dangerous.

Our data for 1922 indicated that the average storm which started fires differed from the average storm which did not start fires in that the dangerous storm had more lightning with over half the bolts directed toward the ground, and had heavier rainfall with the lightning, and more rainfall following the lightning. The 1923 reports fail to corroborate the rainfall conditions, but they agree in showing that the fire starting storms had 48.2 per cent of the lightning directed toward the ground, whereas the non-dangerous storms had only 25 per cent so directed. The comparable averages obtained in 1922 were 51 per cent and 35 per cent, respectively. A rather close agreement, considering that estimates by well over 150 different men were involved. Further evidence tending to substantiate this conclusion consists of the fact that in 1923 the Idaho reports show that 90 per cent or more of the lightning was confined to the clouds in 40 per cent of the

storms, not causing fires, whereas 90 per cent of the lightning was confined to the clouds in 9 per cent of the storms which started fires; a significant difference of 31 per cent.

I am not inclined to accept our data on rainfall with lightning storms. It is the fault of the form as much as the fault of the observers. The form should state that the rainfall durations under the storm are the figures desired. I know that several lookouts always reported the rainfall conditions for their own station regardless of whether the storm passed overhead or was 10 or 20 miles away from there.

Another possible improvement of this form will consist of a change in the heading of the last column. Numerous other improvements can also be made and if any suggestions can be offered we will be very glad to receive them.

Discussion of Gisborne's Paper

Gisborne remarked that his notes apply to Idaho, north of the Snake River. He said further that the lookout can report the width of path and apparent direction of the storm, but that otherwise he could not, of course, forecast the fire location. Mr. Flint stated that the lookout man can tell that the storm went over a certain ridge, with or without rain, with a certain number of flashes.

Gisborne - One interesting question is, does the passage of one storm break up conditions so that the next storm will follow another path? The maps seem to indicate this partially.

There are three time-saving and security elements in connection with lightning fires: (1) the lookout can see the storm in advance; (2) the Weather Bureau can forecast even in advance of this; (3) after the passage of a storm the lookout can report the number of flashes or the number of smokes; he can check the points where bolts strike and watch these points afterwards.

Show - A few hours of advance notice of fire will, of course, permit pre-organization of suppressive forces.

Gisborne - The elapsed time between sighting the storm and sighting the fire should, of course, be reported. In this connection it appears that 25 per cent of lightning storms cause fires.

Kotok - Check should be given by reference to individual fire reports.

Gisborne - The trouble is that we can rarely positively identify the fire with a particular storm. Estimating the direction of a lightning storm is not an easy matter. The general direction of lightning storms is east and southeast, but they come from every direction.

Cox - Generally speaking, thunderstorms take the direction of the general storm area; this applies to general and sometimes to local storms.

Flint - Would it be desirable for Districts 1 and 6 to coordinate their storm forecast work?

Gisborne - It would be decidedly desirable.

Osborne - This could be done. We have cooperated with District 5, though this was not continued last year.

Col. Greeley - How closely can zones of lightning storms be mapped? Fires appear to be bunched in northern Idaho 10 to 1 as compared with eastern Oregon.

Kotok - We have plotted storm paths in District 5 and new paths are not over 2 per cent.

Flint - Lightning fire zones can be definitely drawn (as contrasted with lightning storm zones). There seems to be a definite relation between lightning fire zones and main stream beds in Oregon, but not in Idaho. As a result of lightning fire zone maps we have been able to make shifts in the organization. A question which has not been determined is whether there is also a relation between timber type and geology.

Osborne - The course of lightning fire zones with streambeds is pronounced; the fire zone is not right in the streambeds, however, but upon the lower parallel slopes and spurs. The plan used in District 1 involves a central dispatching system, which permits charting from one lookout to another. The lookouts sight every flash, taking horizontal and vertical angles and locating the strike on map by pin point. Usually there is a puff of smoke when the bolt strikes. Frequently a crown fire starts at once. If necessary, the lookouts watch the points where the bolts strike for a week.

We have a good many dry storms; they are the worst. But many fires start in storms with rain. The biggest disasters from lightning storms have resulted not so much from peak load storms as from moderately light, dry storms.

Weidman - In District 1 some dry storms set fires, but most of the storms that set fires are accompanied by rain.

Osborne - A storm detector, which appears very practical, has been used to advantage commercially. Static conditions set up several hours in advance of a storm cause a bell to ring. An idea of distance and direction is given.

Flint - The two seasons over which our studies have extended have had only 300 or 400 fires per year as compared with the peak of 1200 fires, so these years have not been bad fire years; but the observation is that lightning storms do not set many fires. This is especially true in the West, where there is too much water and too little fuel, as compared with the eastern part of the District.

Show - We are preparing to pool our records with industrial companies which are taking data.

Clapp - Are there other districts in which lightning is important?

Marsh - Lightning is a prolific source of fires in District 3 (Colorado Plateau). On the Coconino Forest, 25-30 lightning fires are sometimes reported within a few hours.

Morse - There is a very distinct zone, extending 50-60 miles northeast from a point on the Payette Forest, where the lightning fire hazard is very serious. District 4 should have help from Flint and Gisborne.

Osborne - In our district, when there is a report of a lightning storm, every man is required to report to the telephone.

Flint - When a lookout reports a storm over a certain area, the men in that area are held on the phone.

## Static in Relation to Lightning Fires in Pacific Northwest

J. V. Hofmann

In the study of static both loop and high aerials are used, the loop for direction and the high aerial for intensity. The loop is accurate for two degrees for short distances and proportionately for longer distances. The coherer system is used.

Static is a very definite part of atmospheric conditions. The question of its relation to humidity is yet to be answered. To correlate static with humidity changes continuous records are needed.

Static is most important in the latter sector of the low pressure area. There is a dead spot between beginning and ending of static by which these can be differentiated.

The commercial stations which are attempting to establish static centers supply hourly reports amounting to from eight to ten per day. It is apparent that static is a variable atmospheric condition having a definite, but as yet unascertained, relation to humidity. The local storm develops rather short wave static. As it accumulates there is developed a decided increase in voltage; this affords a means of differentiating between general storms and lightning storms.

Discussion of Hoffmann's Paper

McCarthy - What is the purpose of the study of static conditions?

Hofmann - The purpose is to predict humidity conditions and secondly, to predict thunderstorms.

McCarthy - Why does not the weather map cover the range your static predictions cover?

Hofmann - Lower pressure areas do not necessarily mean relief. They may bring a higher humidity or a lower one. Static is plotted every day on the weather map to determine its relation to high and low pressure. A high pressure area is always a dry; but high pressure may or may not bring low humidity.

Kotok - Has the Weather Bureau abandoned static work?

Hofmann - No, but it has not compiled its data. We got our static data from Dr. Marvin through Mr. Wells, the local forecaster at Portland, Oregon. These data include the Navy Department records.

Gisborne - What is static? Certain texts do not use the term.

Hofmann - It is atmospheric electricity.

Gisborne - Atmospheric electricity is controlled by four different conditions, only one of which includes weather. These conditions are (1) storms, (2) voltage near sending stations, (3) "cosmic" conditions, and (4) miscellaneous. How can weather conditions be isolated?

Mr. Gisborne submitted the following quotation on the subject of static, from the Scientific American for October, 1923:

"Six papers in Radioelectricite," issues for July, 1922, to February, 1923, deal very thoroughly with the various possible sources of atmospherics or "parasites" encountered in everyday practice of wireless telegraphy, and discuss in very great detail the numerous methods which have been employed by the authors and others to eliminate the trouble. In the first paper the authors classify atmospherics as follows:

(a) Atmospherics due to storms (accompanied by lightning flashes).
(b) Local atmospherics due to voltage fluctuations in the atmospheric layers near the receiving aerial.
(c) Cosmic atmospherics, originating outside the boundaries of our planet, possibly having solar sources.
(d) Miscellaneous, presence of clouds, temperature of the air, atmospheric pressure, etc.

The authors have devised a means for measuring the relative intensities of the strays and the normal signals.

Duff, in his "Text-book of Physics, 1921," states that "the causes of atmospheric electricity are not definitely determined. Evaporation, friction of the clouds, the action of ultra-violet light, and of radio-active materials are some of the causes suggested."

Also, Huntington, in his "Earth and Sun" states that "the electrical and magnetic phenomena of the earth fall into at least four great classes, namely, magnetism, auroras, earth currents, and atmospheric electricity.

"The variations in atmospheric electricity from hour to hour, month to month, and year to year, show a strong agreement with those of magnetism, auroras, and earth currents.

"That atmospheric electricity has some effect upon atmospheric pressure is generally agreed, but whether that effect is large enough to be of any appreciable significance in producing changes of weather is not clear.

"Solar activity is associated with variations in ordinary radiation; these alter the earth's temperature; the differences in temperature give rise to convection and to changes in barometric pressure; and the convectional and barometric conditions lead to variations in atmospheric electricity." Page 172, but on page 179, "barometric conditions can scarcely be the cause of the electrical conditions, as is often assumed."

Report of the Committee on Fire Forms

The Fire Forms Committee discussed the present kinds of various changes and the forms having to do with fire statistics collected by our own organization Form 929. Particular attention was given to the individual fire form. Only a few changes are suggested, and it appears that the criticisms that have been directed towards this Form had been unfounded.

Under "Damage to Reproduction" one column should indicate the per cent of reproduction killed. From the present classification as given it is impossible to arrive at a definite figure of damage. It is believed the addition of this column will bring about the necessary clarity.

Under "Direct Costs" a statement should be made somewhere on the Form where the cost is paid by others than from Federal funds. The cost of the fire is paid by the person responsible for starting the fire without resorting to law enforcement.

Under the "Section of Elapsed Time," the columns at the right should be enlarged to provide for hours and minutes.

Under "Action Taken" in "Steps in Control" on 929 are three lines. This should be supplemented by a fourth which would be a statement covering the "date on which the fires burned most fiercely__________; percentage of area covered on that date__________; hours during which the most rapid spread occurred__________."

The Fire Research Committee should correlate the studies between regions and make certain all Districts carry on uniform studies, and not leave it to the judgment of the individual District.

Your committee also considered the Supervisor's 10-day report, and have made recommendations to Operation covering the changes that should be made.

The attention of Operation was also directed to the necessary revision which should be made in Sheets A-K, which do not correspond in classification to the headings on 929. Operation has already secured comments from the field on these Forms.

The Lightning Study Form has been carefully considered by the committee and revisions have been made. These Forms will not go to the printer for use this coming season.

## Report of Committee on Forest Fire Research Program

### I. Summary of Major Recommendations

1. That a special effort be made to analyze, interpret, and put to practical use all available statistics on forest fires; and that such work be done in cooperation between the administrative and investigative forces.

2. That increased emphasis be placed on studies of the nature, extent, and appraisal of fire damages.

3. That a joint progress report on studies having to do with the prediction of fire conditions be issued as promptly as possible; and that investigators in this field make a special effort to keep in touch with and try out the results being secured by others.

4. That the Forest Products Laboratory, in cooperation with the Experiment Stations, continue its study of the development of instruments for the determination of the inflammability in place of important fuels.

5. That studies having to do with the prediction of fire conditions make full use of all Weather Bureau data and be conducted in the closest possible cooperation with Weather Bureau officials.

6. That the Weather Bureau be requested during the fire season to send out special weather forecasts from the District Forecasters at Washington, D. C., Chicago, Ill., Denver, Colo., and San Francisco, Calif., to such Forest Service officials as may be designated in the region concerned.

7. That the Weather Bureau be requested to supplement this service by assigning meteorologists to District 1, District 6, District 5, the Lake States, and jointly to the Northeastern and Appalachian States, to work with Forest Service men in the local interpretation and application of weather forecasts and in other phases of the fire hazard studies; and that the Forest Service offer to join with the Weather Bureau in requesting an appropriation for this purpose.

8. That the Forest Service offer to arrange for the securing of records from such additional stations as the Weather Bureau may designate as desirable to increase the effectiveness of weather forecasts for the forested regions.

9. That investigations having to do with determination of inflammability and prediction of fire conditions include the observation and study of actual fires with reference to such points as rate of spread, general behavior, and control.

10. That observations of lightning storms be undertaken by lookout stations in all of the western districts.

11. That slash disposal be emphasized as a problem on which further investigation is necessary, and as the most important phase of the relation between fire protection and forest management.

12. That the existence of a relation between methods of cutting and fire hazard be clearly recognized, and that this relation be given full consideration by administration officers in determining the method of cutting to be used on any given area.

13. That no attempt be made at this time to standardize the methods used in fire studies, but that there be a free interchange of information regarding methods in use by various investigators and a full discussion of their relative merits.

14. That careful consideration be given to the importance of fire studies in relation to other phases of the investigative program; and that as a rough guide, taking the country as a whole and year in and year out, they should not absorb more than one-fifth of regular investigative funds.

## II. Priority of Existing Studies

The fact that a considerable number of fire studies are already under way gives them a certain priority over other studies which might perhaps be regarded as intrinsically more important. Moreover, the relative importance of different studies in different regions is influenced not only by theoretical considerations, but by a wide variety of local factors with which this committee is necessarily less familiar than are the District Investigative Committees and regional Advisory Committees. We therefore recommend that existing studies be given preference in the

formulation of fire research programs, and that our suggestions as to the relative importance of the several groups of studies discussed be interpreted and applied in the light of local conditions.

## III. Fire Statistics

Thorough-going analysis of fire statistics is regarded by the Committee as of immediate and basic importance. The information to be secured from such an analysis is essential for any complete or reliable appraisal of the fire situation; it is essential for the intelligent organization and administration of the protective force; and it is essential in giving a background for investigative activities and in selecting problems most in need of further study.

Strictly speaking, statistical analyses are merely one phase of more comprehensive studies of such problems as fire risk, hazard, liability, damage, etc. We believe, however, that this phase is so important and can be applied immediately to so many related aspects of the whole fire problem as to deserve separate consideration. Illustrations of the field that may advantageously be covered by statistical analyses include such points as the occurrence of fires with reference to cause, location, population, forest type, and date; the size of fires in relation to accessibility, cause, date, forest type, and elapsed time; the relation between number of fires, area covered, and damage caused, and weather conditions; the relation between fire hazard and method of cutting and slash disposal, etc.

The number of relations of this sort on which valuable light can be shed by statistical studies is very large and the individual items are of various importance in different regions. We do not feel competent to express an opinion as to the items on which chief emphasis should be placed in each region. We do, however, desire to stress the importance of making the fullest possible use of all available statistical data even where such data are scant and inaccurate. We believe that an analysis of the available material will be worth while if it does no more than to emphasize its deficiencies and to point out the holes that need filling; and that it will assist in getting the State Foresters and other agencies to secure more complete and reliable statistics.

We recognize that administrative officers have been and are now collecting, studying, and using statistical data. This is an integral part of their duties, and should, of course, be continued. In our judgment, however, these activities should be supplemented by thorough-going studies by investigative officers in order to make the fullest and most effective possible use of the available material. Such studies should obviously be made and the results interpreted in close cooperation with administrative officers in the Forest Service and so far as possible with State Foresters.

Data on both National Forest land and other land should be included in statistical studies. They should, however, be worked up separately in the first instance and later combined so far as the character of the data warrant. In the case of the eastern experiment stations, a special effort should be made to keep in close touch with the State Foresters and to induce them to secure as complete and accurate records as possible of the items on which information is desired. We believe that the annual statement of fire statistics now issued by the Branch of Forest Management should continue to be handled by that Branch, that the points to be included be agreed upon in consultation with the Branch of Research, and that wherever desirable the data be submitted before publication to the Experiment Stations concerned for comment and suggestions.

In the working up of statistical data, we recommend that full advantage be taken of the punch card and sorting machine in the Washington office. This may be done either by sending the original fire reports to Washington or by furnishing the Districts with machines to punch the cards, which can then be sent to Washington for filing and for sorting whenever data from them may be desired. We believe the former method preferable, provided the material can be handled and returned immediately. Otherwise the latter method will apparently be necessary in order to avoid embarrassing the Districts by having the original data out of their files for any considerable time. Arrangements for placing on cards the data for lands not included in National Forests will have to be worked out in accordance with conditions in the various regions.

It should be the aim to build up a complete card file covering all existing data of sufficient accuracy to be of value, and to keep this up to date by adding to it the records for each year. From such a file, data along any desired line can be worked up at any time for use in statistical analyses. We recommend that the items to be included on card forms be worked out by the Washington office in consultation with District Foresters and Experiment Station Directors.

Finally, the importance of prompt publication of the results of statistical analyses of general interest is emphasized. We believe that this will not only make generally available concrete information of practical value, but will stress the importance of such analyses and will make possible an interchange of ideas as to objectives and methods that will be helpful to all workers in this field.

## IV. Fire Damage

We find it difficult to place any other group of fire studies as unquestionably and universally second in importance to analyses of fire statistics. We have no hesitation, however, in expressing the belief that studies of fire damage have not so far received sufficient attention. Such studies are needed to determine the exact nature and extent of the injury caused by forest fires of varying severity and under different forest conditions; and to work out practical methods for appraising and expressing such injury. Statistical analyses of existing data are important, but physical studies of fire damage, both direct and indirect, are

also essential for a thorough understanding of the problem and for increased accuracy in the collection and interpretation of future statistics.

As in the case of fire statistics, we feel that it is impossible to state definitely the particular phases of fire damage that should be emphasized in any given region. We do, however, believe that the more tangible effects of forest fires should be taken up first, such as damage by size classes, species, and types in burns of various intensities with reference to mortality, reduced growth, insect and fungous injury, and amount and value of forage. Studies along these lines will pave the way for the more difficult investigation of damage to soil, watershed values, fish and game protection, etc. It is to be anticipated that as studies of fire damage progress they will lead more and more to fundamental investigations in various fields.

The results of fire damage studies should be expressed in terms readily understandable by field men, and should be developed into methods that can be used in the administrative determination of fire damage. Studies should not be regarded as complete until they have reached a point where it is possible to issue specific instructions for the appraisal of fire damage, developed in cooperation between the administrative and investigative forces. In certain aspects, such as the determination of stumpage values to be used, the application of expectation and replacement values, and determination of rate of interest, the active cooperation of the Office of Forest Economics will be needed, as well as the results of investigations by the Experiment Stations in other fields.

## V. Prediction of Fire Conditions

Studies aimed at the prediction of fire conditions as a means of increasing the efficiency of the protective organization have been rather generally undertaken. We believe that they are securing information of real value, but doubt the advisability of undertaking similar studies on an extensive scale by stations not already involved in the work in priority to studies along other lines.

We recommend that studies along these lines aim to cover five specific points:

(a) Determination of the inflammability in place of important fuels.

(b) Relation between meteorological conditions and inflammability.

(c) Prediction of weather conditions for as long a period as possible in advance.

(d) Determination of probable fire hazard in the light of expected weather conditions and resultant inflammability.

(e) Prediction and identification of early fire seasons.

The work so far done has resulted in emphasis being laid by different investigators on different phases and different methods. We feel that these differences are advantageous rather than otherwise and that it would be unwise at this time to attempt any standardization of methods. We do, however, believe and recommend that all studies, irrespective of the method used, be aimed at answering the questions already indicated. We also recommend that in addition to specializing along his own lines, each investigator keep in touch with and just so far as practicable try out the results being secured by other investigators.

As an assistance in doing this, we urge the prompt publication of a joint progress report embodying the results so far secured by all investigators in this field. We believe that such a publication will do more than any other one thing to arouse interest in the work, to secure such uniformity of attack as is desirable, and to inform investigators of results so far secured by others in the same field. Subsequent reports, including as far as possible the work of all investigators, should be published as rapidly as justified.

We do not feel competent to prescribe precisely what measurements of meteorological factors should be taken in connection with the work in each District. We do recommend, however, that each investigator inform himself as to the records being secured by other investigators, and that he secure similar records in connection with his own work so far as this may be practicable. Uniform observations over a large region will gradually build up a mass of comparable data that will be of value in the testing out or application of any given method. The meteorological studies of forest types by several western investigators have already been helpful in this direction and have given us a substantial fund of information regarding conditions in various forest types. In most districts, at least one fairly complete weather station is now being maintained by investigative men.

Attention is also called to the value of statistical analyses of fire and weather records as a means of establishing some definite correlation between the two. It is more than probable that these will prove of value not only in explaining past outbreaks but in the future prediction of dangerous fire conditions.

In connection with the determination of the inflammability in place of important fuels, we recommend the continuation by the Forest Products Laboratory, in cooperation with the Experiment Stations, of the development of instruments for this purpose. So far as additional studies of the relation between the moisture content of various fuels and atmospheric factors can be handled to advantage by the Laboratory we recommend their continuation.

We urge that the fullest possible use of all Weather Bureau data be made in connection with fire prediction studies. Moreover, the fact that the forecasting of weather conditions is primarily a Weather Bureau function makes it important that the studies not only make use of Weather Bureau data but that they be conducted in the closest possible cooperation with Weather Bureau officials. In this connection, we recommend that the Weather Bureau be requested during the fire season to send out special weather forecasts from the District Forecasters at Washington, D. C., Chicago, Ill., Denver, Colo., and San Francisco, California. The individuals to whom such forecasts should be sent is an administrative matter which we do not regard as within our province.

Cooperation with the Weather Bureau in this respect should be supplemented by the placing in the field of five meteorologists to work with Forest Service men in the local interpretation and application of the forecasts and in other phases of the fire hazard studies. We recommend that these five meteorologists be assigned to District 1, District 6, District 5, the Lake States, and jointly to the Northeastern and Southern Appalachian States. Since it is understood that the Weather Bureau does not now have sufficient funds to employ such men, we recommend that the Forester take the matter up with the Chief of the Weather Bureau and offer to join with him in requesting a sufficient additional appropriation to cover their salaries, expenses, and other expenditures connected with the work, such as the purchase of equipment.

We understand that the effectiveness of the special weather forecasts recommended would be increased by the securing of additional records from areas not now thoroughly covered by meteorological observations. We therefore recommend that the Forester offer to arrange for the securities, through Service men or through cooperation with State Foresters or other agencies, of records from such stations as the Weather Bureau may designate as desirable for the purpose. Provision for the equipment of such stations should be made in the appropriation already referred to.

In this connection, we suggest that the Forester take up with the Chief of the Weather Bureau the importance of more complete and comparable evaporation records and the desirability of such investigations by the Weather Bureau as may be necessary to make it possible to secure them. Cooperation with other agencies such as State Departments, Agricultural Colleges, Universities, and private organizations may be desirable in connection with the meteorological and other phases of the project. We recommend the desirability of a survey looking toward possible cooperation with such agencies by all investigators in this field.

Studies of lightning storms constitute a special phase of the fire prediction work. In addition to the continuation of the present activities in this field, we recommend the securing of observations of lightning storms by lookout stations in all of the western districts. We believe that information along this line is needed for the entire West and

that the Service should start to build up as complete and accurate records as possible even in Districts where no investigative man is at present available to analyze them. They will unquestionably prove useful later and in the meantime may prove of value in Districts where special studies of the problem are already under way.

We recommend the uniform use of the lightning storm observations form approved by the Forms Committee of the present conference. Full use should be made of the punch card and sorting machine in the Washington office for the tabulation of data, while the analysis and interpretation of the data should be handled by the field investigator, working in cooperation with the administrative men.

We recommend that the men in Districts 1, 6, and 5 who are engaged in fire prediction studies arrange for an annual meeting at which they can go over work of mutual interest. We also recommend that studies within this field include the observation and study of actual fires. We believe that such study is essential for the intelligent interpretation and practical application of the results as to inflammability and its relation to weather conditions and fire hazard secured through instrumental measurements and observations that are virtually of a laboratory character.

## VI. Slash Disposal

In spite of the work already done on slash disposal we believe that much investigation is still necessary. This should cover such points as the fire hazard created by slash of different kinds and in different amounts; the duration of the period during which the hazard exists; the effectiveness and cost of different methods of slash disposal; and the relation between the form of forest management used and the resulting slash danger.

We believe that studies along these lines should be undertaken in the near future by the Northeastern and Lake States Experiment Stations and District 1. The desirability of further work along these lines should be considered in the other western districts, provided it can be handled without overloading the program. The subject has not been discussed at the conference and we do not feel in a position to go further in the way of specific recommendations, except to add that any work by the investigative force in this field should be done in close cooperation with administrative officers.

The fact should not be overlooked that slash disposal is also important from other aspects than that of protection from fire. The relation of slash to insect and fungous attack and its relation to reproduction are matters deserving thorough consideration and study. Looked at from this angle, slash disposal becomes to a lafge extent a problem in forest management. We regard this broader consideration of the slash

disposal question as essential and believe that it should receive due attention in the development of the forest management part of Experiment Station programs.

## VII. Fire Control and Forest Management

In addition to slash disposal, fire control is an item which should be considered in other aspects of forest management. More information is needed as to the extent to which, if at all, various methods of cutting influence the fire danger not only from the standpoint of slash but as a result of the changes in local meteorological and soil conditions which must necessarily result from any change in the forest cover. We believe that much information along this line can be obtained by a study of available statistics supplemented by field observations, as is also the case with slash disposal.

While recognizing the importance of more thorough-going investigations in this field, we do not recommend that they be given priority at this time over the other fields of investigation already suggested. We do, however, urge making full use of existing data as to meteorological conditions in stands of varying density and in cut-over areas of various kinds and sizes in correlation with the studies of fire hazard as a means of securing additional information of the relation between silviculture and fire control. We also urge that this relation be given full consideration by administrative officers as one of the factors having an important influence on the method of cutting to be recommended on any given area.

## VIII. Other Fire Studies

Special studies of the rating of fire hazard and liability are now being made by the Washington office, Priest River Experiment Station, and District 5. We recommend the continuation of these studies but doubt the advisability of extending them at this time. The development of usable results from the studies now under way may, however, at any time make it desirable to test their practical value and perhaps to initiate work in other districts.

The behavior and control of forest fires is a subject which we regard as deserving of study by the investigative force. We believe that marked increase in the efficiency of fire fighting, particularly in the case of large fires, may be possible from a study of rate of spread as influenced by such factors as inflammability, type, topography, and meteorological conditions. While distinct from studies of fire conditions, it is closely related to them. In view of the heavy burden already being carried by the Research personnel, we are not prepared to recommend any extensive work along this line, but suggest that the possibility of doing something in this direction be considered in connection with the studies of fire conditions in Districts 1, 6, and 5.

Studies dealing with the relative efficiency of different types of tools and other fire-fighting equipment, with the organization of fire-fighting crews, and with similar matters we regard as an administrative matter which should not be studied by the investigative force for the present at least.

The relation of grazing to fire hazard is an important subject which we believe should later receive intensive study. We are not ready to recommend that it be given priority at this time over any of the other investigations suggested.

## IX. Methods

We have already expressed the opinion that it is premature to attempt any standardization of the methods to be used in studying fire conditions. We believe that the same thing is true in the other fields discussed and that the most satisfactory progress will be made by leaving the development of methods for the study of specific problems for the present largely to the initiative of individual investigators.

Standardization becomes desirable only as a result of long experience in which different methods are thoroughly tried out and their relative advantages and disadvantages established by the acid test of actual trial. We do, however, believe in a full and free interchange of information regarding methods and a discussion of their relative merits. Every effort should be made by investigators in the same field to keep each other informed along such lines as these.

## X. Relation of Fire Studies to Rest of Program

We do not feel that we are in a position to attempt to pass on the relative merits of fire studies as compared with other projects in the field of the Experiment Stations. We do, however, believe it important to emphasize the fact that in spite of the unquestioned importance of fire studies they constitute a relatively small part of the investigative field. Moreover, it is reasonably certain that the loss due to forest fires is much less than the loss in possible production due to improper methods of forest management. Care must, therefore, be taken not to expand the fire studies to a point where they will encroach unduly on the time that should be devoted to other phases of forest protection and to silviculture, mensuration, and forest management generally.

As a rough guide to the relative importance of fire studies, we suggest that, taking the country as a whole and year in and year out, they should not absorb more than one-fifth of regular investigative funds. This limitation would not, of course, apply to cooperative funds or to such phases of fire protection as may be regarded as more of a management than a protection problem. Moreover, we recognize that no

such percentage, which is necessarily more or less arbitrary, can be inflexibly applied, and that at certain times, both because of the immediate urgency of fire problems and in order to avoid the scattering of limited resources over too wide a field, it may be desirable to concentrate on fire projects to a greater extent than that suggested. In Districts where a very large proportion of the investigative funds is now devoted to fire studies, we recommend no immediate change. We do, however, urge serious consideration of the relative importance of fire studies as compared with other management problems when additional funds become available, and more particularly in the formulation of programs for the newer stations.

S. T. Dana, Chairman
H. T. Gisborne
E. W. Kelley
E. F. McCarthy
S. B. Show

Outline of Essential Information for Individual Fire Reports for Fire Control Agencies in U.S.A.

State

County

Ranger District or Political Township or Grant or

Township, Range and Section (Supplemented by a map of area for all burns over 10 acres)

Number or name of fire

Date of fire

Class of material in which fire started - grass, slash, leaves, etc.

Causes

- Lightning
- Railroad
- Campfire
- Smokers
- Brush burning (Not slash burning by loggers)
- Incendiary
- Lumbering
  - (Logging machinery)
  - (Slash burning)
  - (Sawmills)
- Miscellaneous
- Unknown

Class

a. Less than 1/4 acre
b. 1/4 acre to 10 acres
c. Over 10 acres

Character

Surface
Duff or ground
Crown

Time Record

1. Inception time.

2. Discovery time, and time elapsing between inception and discovery.

3. Report time, and time elapsing between discovery and receipt of report by man responsible for going to the fire.

4. Get away time, and time elapsing between receipt of report and the time first man starts for the fire.

5. Time of commencing work and time elapsing between time of starting by the first man and the time work commences on the fire.

6. Total elapsed time between (1 and 5) and (2 and 5)

7. Date and time fire was extinguished or crew work stopped.

8. Date and time patrol stopped.

Probable area when discovered

Area when reached

Area when extinguished

Character of area burned

Types and area burned of each type

Slash (Age of slash area
(Restocked or not)
[1]Old burns (Age of burn area
(Restocked or not)

[2] ______________________ area

[2] ______________________ area

[1] Where applicable.
[2] Different types burned to be written in.

Area Burned in Acres as to Cover

Timbered

Mature or merchantable timber
Reproduction or young growth
Protection forest (not brush)

Non-Timbered

Brush (not restocking to timber)
Grass
Other

Damage

Merchantable timber

Species
Volume
Value

Reproduction or young growth

Area
Age
Average height
Site
Type
Number killed
Value

Protection forest

Species
Area
Value

Forage

Acres
Value

Forest Products
Improvements
Other
Value
Total Value

No. seed trees left per acre on area burned (Distribution)
No. young trees (reproduction) left per acre (Distribution)
Number of men starting work on fire
Maximum number of men on the fire
Costs
    Temporary labor
    Subsistence supplies
    Other supplies and equipment
    Transportation
        Total
    Salary of regular officers
        Grand Total

Remarks
Weather Conditions
Instructions

Signature of officer making that report.

Signature of approving officer.

Following the presentation of the fire research committee report by Mr. Dana, Chairman, there was considerable discussion as to specific items in the committee's report. It, however, was the concensus of opinion of those present that the committee was essentially right in its recommendations, and it was agreed that the stations and districts should, as far as was possible, follow up recommendations of this committee. Mr. Clapp reviewed these recommendations briefly and said that he would expect the stations to live up to their part of these recommendations, as far as it was within their power. During the coming year he desired that the men give considerable thought to the preperation of a joint publication covering the results of their investigations in fire prediction, or the preparation of separate publications to be issued in such a manner as the Washington office saw fit.

Col. Greeley asked the privilege of making a few remarks on the whole fire discussion, and stated that he desired to compliment the members of the Branch of Research for the great interest they had shown in developing this side of the research work. He said that it was a great source of gratification to him to note the progress which had been made in this comparatively new field of study, the distance to which the men had already gone, and the amount of work that had been turned out. He desired to issue a note of warning upon the tendency of the men to work alone, and develop methods entirely independent of each other. While this is a laudable thing, he wished that the men would enter into the fire study work in the true spirit of research and secure the facts without regard to preconceived notions. Furthermore, he

did not desire the men at the stations to get into the field of pure meteorology, because this was a branch of science in which the Weather Bureau had prior rights which should be respected. He assured the men that he would be very glad indeed to see and further the development of meteorology at the Forest Experiment Stations through the cooperation of the Weather Bureau in the study of the fire weather problem.

Mr. Cox of the Weather Bureau stated that he also was greatly interested in this whole subject as it had been presented and desired to thank the Forest Service for the courtesy of permitting him to be in attendance. Though the field was comparatively new and although he had been interested in a general way for many years, he had no idea that the foresters had gone as far into the subject as they had. He did not believe that there was very much danger of the men at the stations usurping the work or functions of the Weather Bureau, and he assured them that as far as he was concerned, he would be most glad to cooperate with the stations as much as he could, particularly the Lake States Station, which was in his forecasting district. He felt that the Weather Bureau would be glad indeed to cooperate in the work and as funds permit, in the assignment of men to the stations.

Mr. Clapp thanked Mr. Cox for his part in the meeting and the help offered and stated this would be taken up with the Weather Bureau in Washington later.

# PART II. GROWTH AND YIELD INVESTIGATIONS

## Empirical Yield Tables

### Advantages and Disadvantages

C. G. Bates

The writer will argue for the practically universal use of empirical yield tables because at present we are dealing largely with virgin forests and because of the extremely great doubt as to what the effects of management may be in our forests and the improbability of obtaining normal stocking under our present loose methods of management.

An empirical yield table is one showing for any age of stand the amount that can ordinarily be cut if all merchantable material is removed. Such a table takes no account of increment values lost through under or overstocking, nor of the material lost by death during the development of the stand.

It goes almost without saying that our empirical yield tables must differentiate between sites and should be of very local character since the factors of soil, abundance of reproduction as determined by climatic conditions, and many other variables affecting the local characters of stands will be directly reflected in the average yields of a locality.

Empirical yield tables should be constructed on stand tables obtained by strip surveys covering wide expanses of forest, leaving practically nothing to the judgment of the investigator as to what kind of a stand is or is not "average" for the locality in question. Within the length of the strip, sites may be set off according to soil, slope exposure, etc., and similar sites grouped together in considering the results.

In empirical more than in normal tables it is necessary to use judgment in the field to distinguish and describe the different sites, say I, II and III. The yield or stand can not, when office work is undertaken, be used to judge site as it can when only the best stands have been measured, because with wide variations in stocking this factor alone may have greater influence on the yield than a change from Site I to II or from II to III.

The principal advantage of empirical yield tables is their direct applicability to the kinds of stands we are dealing with at present. Likewise the principal disadvantage is that they do not hold before us any ideal in the direction of increased yield to be striven for, and the stand tables which support them do not give information on the ideal or normal stocking.

The uses of empirical yield tables in National Forest management are:

1. To show whether present stands of known age are likely to increase in total yield and value or should be cut at once. This is often a very important question, as there is a very general tendency in the Forest Service to say that in cutting any virgin stand which appears old, we are preventing loss by deterioration or warding off a long period of stagnation. In view of the very probable increased stumpage prices and greater demand for National Forest timber within 20 or even 10 years, we are no doubt often sacrificing both quantity and price at this time through lack of knowledge as to when stands begin to "go back."

2. To prognosticate in a rough way what yields may be expected during the next cutting cycle from stands now plainly immature or those which are now being cut over in part. With young stands which we cannot now touch because of limited markets for small material, the application is extremely direct and simple. With present stands from which the largest and oldest trees are being cut, the prognostication of future yields is at best only a guess since, as said at the outset, we know little as to how these stands will grow under the most ideal conditions, and still less with the understocking which is the usual heritage of our timber sales. In my opinion the safest basis for calculating this future yield is to assume the age of the trees left to correspond to their average diameters (even though they may be the suppressed individuals and much older than they appear) and to assume that they will increase at the rate indicated by the yield table for that age, with a reduction equal to one-half the percentage of understocking. In other words, if the understocking amounts to 50 per cent of an average stand as shown by the empirical stand tables, we cannot expect more than 75 per cent of the average increase in volume for the given period, even though the individual trees left show greatly stimulated growth.

While these uses of empirical yield tables are important in National Forest management primarily that we may put the forests on a sustained yield basis and obtain the maximum safe cut from every acre, it is even more important for private forestry that there should be reliable yield tables from which may be computed the period of maximum return, based on the average stand present on the ground, rather than any ideal of forestry. Such information may in many cases prevent the untimely cutting of immature forests, and in localities where the returns from forest growth are really profitable, should encourage planting or conservative logging on a businesslike rather than a sentimental basis.

<u>Pearson</u> - Regardless of number of trees on a plot, trees in the upper diameter classes are scarce. To fill them out, it might be possible to take trees out of the plot. For trees below 4 inches, use a strip method taking all trees, even seedlings. Felling the trees depends on the purpose of plot.

Dunning - Smaller trees do not enter into the volume of the stand and can be omitted. The dominant trees or those in the upper diameter classes are really the volume makers. Volume tables should be correct and local volume tables should be constructed for each plot.

Dana - Paint and tagging have different relative merits.

Forbes - Paint is necessary for advertising purposes, and with the Southern stations is necessary for the tags are often removed. It is necessary to scrape the bark to get a smooth surface for painting. The point of measurement should be marked.

Shepard - Can the card system be used for computing yields?

Munns - The use of the machine tabulator is adaptable to almost any purpose and much of the compilation involved in sample plot work can well be done by this method. A plan has already been worked out whereby we can apply the machine work in site volume table work. It has its limitations.

Dana - What basis do you consider necessary for empirical yield tables?

Kittredge - Ten per cent is considered adequate for timber estimates.

Bates - Considers 50 one-acre plots with a number of different age classes represented as being generally adequate.

Dana - Would it be possible to use ordinary reconnaissance data?

Bates - This would depend on accuracy and intensity of the work.

Dana - Suggested the possibility of combining the two.

Kittredge - In connection with intensive reconnaissance work data was collected as a bssis for empirical yield tables in connection with the regular timber survey work.

Forbes - How wide an application would you give the yield tables?

Bates - Many factors of site and stand density would be reflected in the tables, and as soon as they appreciably influence yield, should be recognized.

Clapp - On the National Forests would separate working circles require separate tables?

Bates.- In all probability, if conditions were sufficiently different.

McCarthy.- If a certain percentage of a stand is needed for an estimate, the extra variable of age should increase the percentage required for accurate yield tables.

Normal Yield Tables
Thornton T. Munger

Without yield tables proper regulation and management is impossible. It is unfortunate that so little progress has been made as yet in yield tables for National Forest conditions. This should be made a major line of endeavor for the next decade, in most quarters at least.

Shall the tables be empirical or normal? There should be unanimity of endeavor so that efforts will not be duplicated or wasted; some standard policy for the style of yield tables should be decided upon. Details of form need not be standardized.

Normal tables, or index tables, indicate the yield that may be expected from a reasonable fully-stocked average stand of sound trees protected from destructive agencies. They bear the same relation to empirical tables that standard regional volume tables for the full scale of sound trees do to local volume tables made for a run of average trees measured according to local usage.

Normal tables for even-aged stands are easy to make because in most regions there are plenty of stands available for study, both mature and immature, which are normal.

The chief misunderstanding of normal volume tables is the term "fully stocked." This does not mean the maximum number of trees or the maximum yield obtainable. It means that the ground space (or root space as the case may be) is occupied as fully as is customary in natural woods. Overstocking gives abnormality as well as understocking.

For American National Forest conditions, normal tables will usually not be for planted stands; that is a separate problem. Tended woods will often give yields above those of standard normal tables. Nor will most American tables assume that the stand is to be thinned periodically.

The kind of tables which American foresters need now will show the yields that natural, untended stands can actually produce at various ages under satisfactory growing conditions.

For scientific study and for comparison of one type or site with another, normal tables are the only style of table worthy of consideration. In actual forest administration normal tables are the basis to work from - the standard with which to compare actual yields. In the application of normal yield tables to large areas for management purposes, some discounts must be made ordinarily, but this is not the same as making and applying empirical tables.

The discounts are on account of (a) blanks in the forest due to site conditions not accounted for in the working plan type maps (these remain constant), (b) blanks or thin places due to understocking (these tend to disappear), (c) accidents and castatrophies and the difference between full volume and usable volume of the individual trees, i. e., rot, breakage, shake, etc., not accounted for by the volume table on which the yield table is based (these latter factors are very variable).

Natural stands tend to become normal if abnormal, i. e., overstocked stands reduce to the normal number of trees per acre. Understocked stands become less understocked as they get older. Hence empirical tables have a temporary use only and are dangerous in long time predictions. Empirical tables are also very local in their application, for the factors which render a stand subnormal in the locality where an empirical table is made may not obtain in another locality of the same type.

Trying to use empirical tables in forest regulation has the fallacy of presupposing that past conditions for growth will be repeated in the future. The chief use of yield tables is to predict the returns that may be secured in the future. An intelligent prophecy based on a standard normal table is better than a forecast made on the basis of past growth as shown by an empirical table.

For National Forest use, as well as for application on private lands, normal yield tables based on natural stands are recommended. Special conditions may demand normal tables based on planted stands.

Rather than spend time making empirical tables for local and temporary use, it is urged that foresters supplement their standard basic and universally used tables with factors which will make them applicable for any set of conditions. Such factors as the following are needed. They are best expressed by percentages.

(a) Range in number of trees per acre for each site and for each age that constitutes normality.

(b) Discount for understocking due to blanks that may be expected at maturity.

(c) Factors of difference between predicted and used volumes, dependent upon class of product, intensity of utilization and defects.

McCarthy - Would Munger consider the making of separate tables for each species necessary within a type.

Munger - The work of the Appalachian Forest Experiment Station has shown that the yield for a type is quite uniform and would be better by types.

McCarthy - In making a yield table for a single species we seldom find 100 per cent pure stand. Would Mr. Munger favor making tables in terms of that species alone or adjust to the basis of a pure stand?

Munger - Stands over 75 per cent of a single species are usually considered pure. If the secondary species are to all intents and purposes the equivalent of the major species, I would include them. If the species in mixture are inconsequential in the final yield, they may ~~bx~~ better be ignored. There is no objection except for simplicity's sake to including the several species where they are all of consequence, as in the usual European practice.

Dana - It is not yet clear to me what Mr. Munger means by a normal yield table.

Munger - They would cover a representation over large areas of the kind of stands which we may expect to get under management.

Frothingham - Would Mr. Munger consider the use of the term "well-stocked" instead of "fully-stocked?"

Munger - Favors the term as being significant.

## Choice of Yield Tables from the Standpoint of Administrative Needs

Elers Koch

Naturally, in deciding what kind of yield tables we want for use in National Forest work, we must first ask the question, just what do we want to do with them? What information do we need which yield tables of some sort should give?

Speaking primarily of even-aged stands, there are two things particularly which we need to know before management plans can progress; first, what will the young stands now existing yield at maturity; second, at what age is that maturity reached? or, in other words, what should the rotation be?

There are at the present time in District 1 vast areas of even-aged young growth resulting from past fires in the white pine type, the larch fir type, and the lodgepole pine type. Most of this is 30 years old, following the 1889 fire, or 10 years old, following the 1910 burn. There are, of course, other immature age classes represented, some 60 to 80-year stuff, and a good deal of 100-year old timber just approaching maturity, but the 10-year-old and 30-year-old classes predominate, covering whole mountain sides or whole drainages with a uniform, dense growth of even age.

The same condition must be true of the Douglas fir region in District 6, and of all the lodgepole region.

In working out the annual cut for management plans, the present tendency is to discard all formula methods or other over-refined calculations, and allot the present mature timber plus the estimated yield at maturity of the intermediate age classes over the period when the predominating 30-year class is ready to cut. This is a simple and satisfactory method, and easily applied, provided it is possible to predict yields at or about the rotation age.

The information secured as a basis for several recent management plans in District 1 consists of a complete age class and type map, and an estimate of the timber of merchantable size by types and age class. Nothing is obtained for the younger age classes except type and age.

The important thing which is needed is a determination of what these big areas of even-aged young growth are going to yield at or around the rotation age. Yield tables are intended to furnish this information and the question is, what kind of yield tables will give the answer most accurately and with the least amount of work in application of them?

Normal yield tables furnish a standard of measurement based on fully stocked stands divided into three to five site classes. It is obvious that to apply normal yield tables to natural stands as they run, it is necessary first to divide those natural stands into site classes to correspond with the yield tables, and, secondly, to secure sufficient basal area or other measurements to determine the departure from normality, and thus secure a reduction factor to apply to the normal yield tables.

This means work and expense. It means a detailed cruise of all the young growth area to classify sites and to measure sample areas. If there is an easier and just as accurate or more accurate way to get at what we want, why not use it? Regional empirical yield tables are the answer at least for the time being, while we are making our first rough plans.

There are in District 1 whole sections, sometimes even whole townships of even-aged timber 100, [illegible] or 140 years old, which have come in as a result of past fires, and which cover the hills without a break, undisturbed by cutting or fire, and representing the natural growth over these areas. These are like vast areas of young growth which have been established in a similar way after later fires. It is reasonable to assume that if a series of yield plots are taken mechanically from creek bottom to ridge top over several representative areas of even-aged timber, that the average yields obtained on

these plots will represent fairly closely the yields which may be expected on similar areas of even-aged young growth of the same forest types in the same region. In other words, the degree of stocking and percentage of good and fair sites in the younger age classes will average close to the measured plots in the older age classes which have been established in a similar way after extensive fires.

Such empirical yield tables would often be applicable over perhaps three or four forests. For example, one set of such tables for the white pine type could be applied over the Coeur d'Alene, Kaniksu, Pend Oreille, Kootenai and Cabinet Forests, and another set to the Clearwater and St. Joe, without too great a factor of error. It is probable that actual averages of yields which have been obtained over considerable areas will be a closer prediction of yield of similar large areas of young growth than could be obtained through the use of much more intensive methods of classifying the young stands into site qualities, measuring basal areas, and deriving a reduction factor to apply to normal yields which would probably be 100 to 150 per cent higher than average yields.

If rotation is based on the culmination of mean annual growth it is possible that empirical yield tables based on average stands as they exist will give a truer figure than a curve based on fully stocked or normal stands.

My conclusion is that regional empirical yield tables for even-aged stands are of more value for immediate application and use in the management of the National Forests than normal yield tables, and that they should be given precedence. There is the further advantage that the preparation of empirical tables will serve to locate suitable stands and afford much valuable information to be subsequently used in the construction of normal tables.

Aside from use in forest management plans, there is another important need for information on yield, that is in connection with encouragement of private forestry. If we are trying to interest timber owners in the Douglas fir region or the white pine region in Idaho in the possibility of practicing forestry on their lands, the first question which is going to be asked will be, "If I cut my timber in such a way as to reproduce it, and protect that reproduction from fire, how long will it take to produce merchantable timber, and what yields can I expect?" Empirical yield tables for the region will come a lot nearer answering that question satisfactorily than normal tables. In the first case we can say, "Here are yields which have been actually produced over large areas of average land as a result of natural reproduction. If your holdings are about average you can confidently expect these yields." On the other hand, we give him a set of normal yield tables for three to five site classes, and tell him to take his choice, and further, to make such reductions as he sees fit for variation from normal stocking. There isn't any question as to which is

the more satisfactory answer. When the timber owner has his young stands established and wants to do some closer calculation, it will be time enough to give him the normal yield tables.

Show - With the general policy of partial cutting in the Sierra Forests, growth prediction is the most important question on which information is desired. Stands will be essentially even-aged following the next cut. The average best stands that were found to exist in even-aged forests were used as a basis for the California yield tables. Normal yield tables, meaning average best, meet the needs in California both from the standpoint of the operator and the forester which are as follows: (1) In present uneven-aged stands growth prediction following the first cut and (2) normal yield tables for use following the second cut.

Behre - There is a difference in the views relative to the empirical yield tables as brought out by Bates and Koch. It is possible that the empirical yield tables may be just as low as normal yield tables may be high. We should set a standard which will give satisfactory average yields. In so far as possible we should strive to get tables which will eliminate necessity of making corrections. Average stocking instead of basing tables wholly upon fully stocked stands would probably be desirable. There is a decided need for a compromise table which will eliminate the need for correction factors with the future need tending toward future need for normal yield tables.

Frothingham - At the present we are integrating yield tables. In constructing yield tables the possibility was tried out of dividing plots into five classes of stocking. It is thought that ultimately this proposal has some merit.

Forbes - How did Mr. Munger arrive at the conclusion that the range in number of trees per acre for each site and for each age constitutes normality?

Munger - There seems to be some difference of opinion here. The number of trees rather than volume may be a better criterion. We may occasionally have to use empirical tables as a temporary expedient but we will have much more use for normal yield tables. We are not considering stands which have reached maturity; but only stands which have not reached maturity. Within certain limits the number of trees per acre is fairly well fixed for a given age and site.

Clapp - Mr. Bates, do you regard the empirical yield table as a temporary expedient?

Bates - Yes. We will be gradually working toward use of normal yield tables.

McCarthy - I suggest that we consider these fundamental principles on the basis of the use to which tables are to be put. Has the question of yield for uneven-aged stands been considered?

Pearson - We want to know the cutting cycle or period of return. It appears that for a long time we will have to content ourselves with studies of growth after cutting. In the Southwest we haven't the material upon which to base normal yield tables. Some localities will need empirical yield tables; others normal. There is a distinct need for both kinds of tables.

Clapp - Mr. Show, what are you going to do in California in connection with management plans now being formulated?

Show - The immediate problem is one of growth prediction for trees reserved in first cutting of original forest. For these research has available data both on growth and loss by death, which have been secured on permanent plots. These trees will be taken in 30-50 years, i. e., at second cut. Additional volume then will come from trees not now merchantable, especially large poles. Similar data is furnished for them.

Additional information is secured by study of old private cuttings; this is generally taken by technical men on forests.

Normal yield tables for even-aged stands are wanted by Forest Management to aid in figuring annual yield on given working circle.

Kittredge - The fire types start as essentially even-aged stands. Both even-aged stands and uneven-aged stands should be recognized in the Lake States.

Behre - The problem of yields in many aged stands is much more difficult. A yield table for even-aged stands may be applied in predicting yields from uneven-aged stands.

Weidman - In the western yellow pine type where there is little or no annual growth there is little use for a yield table until the timber is cut.

Koch - Administrative officers should be able to look to the Branch of Research for yield tables for use in making management plans. Heretofore, Research has not carried its work to a logical conclusion - to the point where it can be given practical application.

Munger - In the last 3 years the Pacific Northwest has made 3 working plans based on Hanzlik's studies on the Coast, and Weidman's studies in eastern Oregon.

Dunning - Research spent considerable time on the Lassen working circle gathering data for growth prediction. These data were used in formulating the management plan.

Dana - Forest Management ought to collect more data that would be of use to Research in its job of providing Forest Management with basic information. Cooperation on somewhat the same basis as that between Operation and Research in fire studies would be mutually beneficial. We have what might be termed empirical records - showing the volume which is actually being utilized under present standards; - and normal records - entire volumes if utilization is complete. There is also need for both empirical and normal yield tables. The construction of empirical yield tables is largely an administrative job, but making normal yield tables with their site ramifications is distinctly a Research job.

Behre - What is an empirical yield table for an uneven-aged stand?

Munger - An empirical yield table for uneven-aged stands if plotted on cross-section paper is a straight horizontal line.

Behre - What we are trying to express by normality is the productive capacity of the land. Normal tables are designed to show this. Should not be the maximum but the average best.

Clapp - The situation is at best complicated. We will gain by not making it too complicated.

Kittredge - We have recognized two or three different kinds of yield tables. There is a difference in the amount of time and labor involved in the construction of the two kinds of tables. If empirical yield table data can be collected at the time the timber survey is made, the empirical tables will not be so expensive. But if all the original data must be collected independently the normal yield table will prove to be the cheaper.

Forbes - If we are going to get data for both kinds of tables we should aim to get them at the same time and see that they are properly correlated.

## Yield Tables for Even-Aged Stands

Thornton T. Munger

Unnecessary to review here the fundamentals of yield table production which are set forth in any text-book and are non-controversial and generally accepted. Only those points most open to question will be touched upon. The most important question in yield table discussion is whether normal or empirical tables are wanted. That has been covered under the preceding topic.

Yield tables for even-aged stands will usually be prepared by the Baur method - selecting and measuring a large number of sample plots in stands of various ages and on several sites. More and more it will be possible to check normal tables from the records of permanent plots.

Selection of Plots

If normal tables are in preparation, care must be exercised in the field in the laying out of the sample areas. The stands measured must be fully and uniformly stocked but representative and not extreme. Avoid small plots; those of one acre or larger are recommended for stands past half their rotation age. Further culling of the plots in the office is desirable. Those plots from a given tract which depart widely in their degree of stocking, as shown by basal area or volume, from the average should be thrown out. Horizontal measure should be used on sidehills.

Site Classification

Tentative classification of site should be made in the field. Final determination should be made according to total height of dominant and codominant trees after plotting data in office. Some comprehensive system of site classification of nation-wide application, as proposed by Sterrett, seems a desirable goal.

Age

For yield table purposes the age of the stands measured should be taken as the average age of the dominant and codominant trees.

Unit of Area

It should be the universal practice to express all statements in yield tables on an acreage basis, regardless of the size of the plots.

Number of Trees

As now customary, the number of living trees, regardless of size, should be given in the table. It may be desirable also to have a column for the number of living trees above merchantable diameter. If the stand is pure, according to definition, the incidental species in mixture may be thrown in with the major species. Otherwise they must be cared for in separate columns.

Diameter, Height and Basal Area

Columns will be provided to show the average diameter, average total height, and basal area both for all the living trees or for only those of merchantable size, or only those in the main stand.

Cubic Volume

General practice to include in all standard yield tables the cubic volume of the entire stems of all the living trees, exclusive of limbs and bark. This is most important and should be a part of every normal yield table, for cubic measure of all trees is the only reliable index for comparison or for scientific record. Practice not now consistent from region to region. Suggest for all conifers considering all trees 2.6" and over in D.B.H., computing their volumes on the basis of 8 or 10 feet sections, and considering the tip, if not greater than 4 inches in diameter at the base, as a cone, and disregarding a stump the height of the tree's diameter. Cubic foot volume tables should be made accordingly.

Board Foot Volume

Foresters as well as lumbermen think in terms of board feet and are likely to continue to do so. Hence there is demand that yield tables be expressed in board feet, poor as this unit of measurement is for scientific work. This involves many problems. It is going to be difficult to get unanimity of practice. Standards of present utilization vary between regions. Some foresters want to make the tables show the yield that may be obtained under prospective very close utilization. Others want to hold it down to current practice. Some want to employ the International Rule; others stick to the Scribner.

Since the cubic foot yield column gives the absolute total amount of wood volume produced, which can be converted at any time, to merchantable yield according to any standard utilization, the board foot yield is chiefly for temporary or local use and should be expressed in terms of readily understood and accepted practice. Leave out of the calculation of board foot yields the uncertain variables that depend upon prophesy. This makes it more conservative and safer for immediate application. I recommend that Forest Service yield tables in stating the predicted values in board feet use the Scribner Rule, which is the present accepted standard for the country, that they assume utilization which is close, yet not much beyond the present most intensive practice. I do not believe it practicable to try to make these standards of utilization uniform from region to region. Interregional comparisons must be made from the cubic foot columns. Douglas fir and redwood will not have the same standards of utilization that eastern white pine will. Why assume that they do? Let each table fit the region it was prepared for rather than some remote region.

Thinnings

Tables prepared at present for most regions will not assume that thinnings will be made, but wherever it may be done an effort should be made to get a record of the amount of wood volume that is lost by suppression and death or accident. This is possible in the case of permanent sample plots, where the amount of material which dies between periodic measurements can be recorded; and if yield tables are made from such data, columns should be provided to show the wood volume that is not realized in the final crop, but might be salvaged if thinnings were made.

Show - What would be the basis for rejection of plots?

Munger - To determine the standard for the rejection of erratic plots the permissible deviation in per cent from the average should be slightly in excess of the range within a given site and age class.

The range of ages permissible in a plot is dependent on the habits of the species as to whether establishment of reproduction takes place gradually or over a very brief period.

McCarthy - Why include stump in cubic volumes if limbs and bark are excluded?

Munger - I would not insist on inclusion of stump.

Frothingham - Should bark be included?

Behre - Bark can usually be expressed as a percentage of the wood contents. Where taper tables are used volumes inside bark give more consistent results.

## Yield Tables for Many-Aged Stands

Hermann Krauch

Basis

Diameter, not age. Cannot segregate age classes. Growth of average trees applied to stand table. Acreage basis unreliable.

When Required

Required for all forests managed under selection system, whether they are naturally even-aged or not.

Methods

(a) Temporary Plots

1. Stand table - strip surveys best.
2. Mortality factors - logging, lightning, windfall, insects, all difficult to predict. Fair estimate can be made of losses due to suppression.
3. Determination of growth after cutting - difficult to find areas with representative trees or methods of cutting. Also difficult to apply values because not all trees are affected alike.
4. All steps involved in method subject to error.
5. Application to western yellow pine stands in Southwest. Can probably predict yield of even-aged groups with fair degree of accuracy. Use of accretion borer for determining age. Yield determined by comparison with older groups.

(b) Permanent Sample Plots

1. Stand table as for temporary plots.
2. Growth of average trees and mortality data from permanent sample plots.
3. Accurate results.

(c) Method Applied to Western Yellow Pine in Arizona

1. Volume and increment of average trees based on intensive plots - accurate data based on fractional diameters and nearest foot in height-volume table interpolated accordingly (graphic table).
2. Volume and increment curves.
   (a) Basis and method of construction.
   (b) Principles of curve drawing.
3. Stand and mortality data from extensive plots.
4. Growth of average trees applied to stand table to secure increment - mortality subtracted, volume new trees added.
5. Determination of increment by diameter classes permits analysis of growth which is otherwise impossible.
6. One great chance for error in results is that present volume table may not apply. Form of stems change after part of stand is cut; therefore necessary to construct new volume tables, based on cut-over instead of virgin stands.
7. Questions
   How will data for volume table be obtained except by climbing trees?
   Is dendrometer feasible?

Show - The preparation of stand tables for the application of further data is a function of Forest Management. Research should furnish only the basic data on growth. Are extensive plots justified?

Pearson - The extensive plots are intended primarily to supply data on merchantability (?) and furnish a better representation of larger trees than the small plots give.

Forbes - For growth prediction data it is unnecessary to correlate individual tree growth with area.

Korstian - In southern white cedar a marked correlation has been found between crown-height ratio and form quotient.

McCarthy - Is diameter growth at breast height a fair indication of volume growth?

Behre - The use of form class volume tables would probably measure changes in form due to cutting.

Kittredge - Since extensive stand table data are used in application of yield tables, small changes in form may be consistently disregarded.

Frothingham - In the southern Appalachians individual tree growth has been used as a basis for growth predictions. Average height-diameter curves for dominant trees of several important species based on sites were prepared. Probably only 2 or 3 decades in advance should be predicted.

McCarthy - Paper companies in Canada have been using a strip method combined with circular sample plots at regular intervals. A tree is blazed at the center of the sample plots with the intention of returning for future measurement, the mortality factor is determined from the strips and plots.

Behre - In the South, Chapman proposed using growth predictions from individual trees by diameter, height and crown classes. The crown classes are based on crown height ratios. Sample plots were used as a check.

Munger - The average annual growth in board feet per acre as determined from increment borings in old cuttings have been applied by the use of stand tables.

McCarthy - The large number of variables encountered in mixed all-aged stands in several sites makes it impossible to take enough increment borings to properly represent all the variables. Complete stem analysis would be too laborious.

Pearson - Permanent sample plot records are not of sufficient length to permit predictions of growth for as long as 40 or 50 years in advance.

## Yield Tables for Stands of Mixed Composition

E. H. Frothingham

### 1. Relation of Species to Yield

Many species with which we shall have to deal in yield tables are nongregarious or not markedly gregarious. The acknowledged advantages of mixed forest point to the future development of these.

Assuming other conditions equal, each species has its characteristics of growth which will differentiate the yield of pure stands of the species from that of any other species. No one yet knows exactly what the differential is between any two species; there are too many disturbing factors involved and no definite standard for comparison. In determining the differential between two species under exactly similar growth conditions, an identical system of management, exactly applied, would have to be assumed.

The differential between species of widely dissimilar growth character will obviously be greater than that between species of similar character. On sites fitted for either, tolerant species will produce heavier yields than intolerant, at biological maturity. Mixtures of intolerant and tolerant species will produce greater yields than pure stands of either.

### 2. Relation of Stocking to Yield

Marked differences in yield between so-called "well stocked," natural, pure, even-aged stands of the same species, age, and site are commonly noted in yield table construction. A common practice is to throw out arbitrarily sample plot yields which depart beyond a stated limit from the graphic average for the site. If volume per unit area is a function of leaf surface, the reason for radical departures must lie in differences in amount or activity of foliage which have escaped observation in comparisons of stands having apparently closed crown cover. No standard of normality has yet been set. The standards used in yield tables have been arrived at by graphic averaging. This groups stands of great with stands of lesser stem density, with corresponding differences in average diameter.

### 3. Consistent Accuracy Justifies Yield Tables for Mixed Stands

The variations in site and stocking which necessitate graphic averaging of plots for pure stand yield tables justify similar methods for mixed, even-aged stands, at least when composed of species which resemble each other in growth character. The theoretical objections previously noted remain, but practical accuracy within limits set by numerous variables justify yield tables for even-aged, mixed stands of species relatively similar in growth character. It is possible that these limits extend farther than we realize.

4. Extension of Yield Tables for Mixed Stands by Means of Standard Site Classification

By using a single series of sites based upon height growth, yield tables may be extended to cover not only mixed stands but stands with a considerable degree of complexity of mixture. They may even be extended to accommodate very different species, such as yellow poplar and chestnut oak, growing in practically pure stands. Such tables may be considered expedients, taking the place of more precise species yield tables, but in the Southern Appalachians they are filling a very useful purpose.

5. Examples of Yield Tables for Mixed Stands

a. Second growth hardwoods in central New England.

Spaeth* concludes that "in spite of wide variation in percentages of species in mixture (red oak, red maple, hard maple, gray birch, paper birch, yellow birch, beech, chestnut, basswood, poplar, white ash, and others), for a given age, site, and density the volume in board feet, cubic feet, and cords is constant."

b. "Southern upland hardwoods" in the Southern Appalachians

Yield tables based upon plots obtained in Maryland and southward, mostly by Ashe and Besley, representing different types and mixtures. Heightage site curves, previously prepared from independent data, used in assignment of plots to site and general coordination. Five sites, representing conditions from moist cove (yellow poplar, hemlock, etc.) to dry ridge (chestnut oak, scarlet oak, etc.). Assignment to site classes based upon average age height of normal dominant trees of poplar, red, black, chestnut, or scarlet oak, or chestnut. Chestnut oak used only in chestnut oak type. Plots first assigned to site, then cubic foot volumes plotted, separated into five classes by Baur method, and each class graphically averaged. The five classes made to conform as far as possible to height-site assignments of plots. Analysis of plots as to type and number discarded because they fell in a higher or lower class by volume than by height:

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*Spaeth, J. Nelson, 1920. Harvard Forest, Bulletin No. 2.

| Type | Number of plots: Total | used | % | Discarded Volume: Low | High |
|---|---|---|---|---|---|
| All types | 370 | 293 | 79 | 50 | 27 |
| Chestnut less than 50 per cent | 51 | 33 | 65 | 7 | 11 |
| Chestnut more than 50 per cent | 88 | 76 | 86.5 | 9 | 3 |
| Chestnut oak | 62 | 51 | 82 | 5 | 6 |
| White oak | 51 | 42 | 82 | 7 | 2 |
| Red oak | 11 | 9 | 82 | 2 | - |
| Black oak | 45 | 39 | 86.5 | 6 | - |
| Scarlet oak | 54 | 37 | 68.5 | 13 | 4 |
| Yellow poplar | 8 | 6 | 75 | 1 | 1 |

Discarded plots, by sites

| Site | Number discarded: Total | Volume low | Volume high |
|---|---|---|---|
| II | 8 | 8 | - |
| III | 52 | 39 | 13 |
| IV | 17 | 5 | 12 |

Attention is called to the relatively small percentage of plots thrown out as under or overstocked relative to the graphic average and limiting lines for each site. The comparatively small number which fall out because of high volume relative to height age is also gratifying. The basis of exclusion was rather severe; plots were thrown out for very slight discrepancies between site by height and site by volume. This was inconsistent with retention of plots showing wider discrepancies but still falling in the same site class by volume as by height.

Testing consistency in this respect by graphically averaging data plotted by total basal area on dominant height was used for an incidental purpose. It gives promise as a means of detecting abnormally stocked stands, and has been developed by McCarthy in his yellow poplar study by use of cubic volume instead of basal area. This method has also been used by Korstian as a check on stocking of southern white cedar stands.

Show - With relatively tolerant and intolerant species composing the stand it was found that within reasonable limits composition had little effect on total basal area and volume.

Dana - Is there any way of determining just what portion of the total yield is made up by each species?

Frothingham - This is difficult when many species compose the stand.

## Report of Committee on Growth of Uneven-Aged Stands

Growth of uneven-aged stands should be studied by means of permanent sample plots wherever possible. Yield tables for even-aged stands may readily be built without permanent plots, but some of these should be established in all regions to study the development of such stands.

When it is necessary to predict future growth in uneven-aged or cut-over stands, the method must be determined by the stocking of the stand on the ground. When cut-over stands contain less than 10 per cent of normal stocking it is preferable to place emphasis on the new growth and to predict its future as an even-aged stand, rather than attempting to prognosticate the future of the older trees left.

For typical uneven-aged or selection forests containing normal numbers of mature trees, the net change in volume from year to year is nil. Therefore attention should be directed to immature or understocked or cut-over stands.

In immature selection forests the yield of the near future may be prognosticated on the basis of the diameter growth rate of the dominant portion of the stand.

In understocked or cut-over stands whose present stocking is 10 per cent or more of full stocking two methods of approach are suggested, both of which imply a knowledge of the rate of growth of trees in similarly understocked stands. The first method involves the study of the rate of diameter growth of trees of given diameter classes or other limited groups, and the direct application of such growth rates to stand tables for the area to be prognosticated. Thus it may be stated that 10", 12", 14", etc., trees will become 11", 13", and 15" trees in a given number of years. The corresponding changes in height should, of course, be taken into consideration.

The alternative method is to apply the cubic foot increment of similarly stocked stands, with corrections for normal mortality, to the volumes of existing stands. No attempt is made to prognosticate closely the rates of growth of trees of different sizes, the assumption being that these will be much more variable, and will change more definitely as the understocked stand closes up, than will the total increment per acre. The latter, however, in case long periods are considered, will tend to work back toward the increment rate of fully stocked stands which should, therefore, be known as a guide. In attempting under this method to estimate the future cut, it is only necessary to know the approximate sizes of the largest trees which will then be available, and in which the total net increment for the period, or any part of it, may be harvested.

For either of the above methods of computing future growth, the basic data needed may be obtained from permanent sample plots in cut-over areas, or from temporary plots in which the rates of growth are determined either by increment borings or stem analyses covering the period since cutting was done. The method of stem analyses promises greatest accuracy in the matter of volume increments. Such plots, or more extensive areas, may also serve to give information on normal mortality in such stands.

C. G. Bates.
R. H. Weidman
G. A. Pearson
E. H. Frothingham.

## Report of the Committee on the Type and Use of Yield Tables

### I.

### Importance of Building Up a Series of Reliable Yield Tables for the Entire Country

The discussion at the conference has brought out strikingly the dearth of satisfactory yield tables, yet the need for such tables is very apparent. It is urged that means be taken to build up as fast as possible a series of yield tables covering the principal even-aged forest types of the country, these tables to be correlated to an accepted site classification, and to cover both National Forest and private forest conditions.

### II.

### Definition of Even-Aged Stands

The forest growth considered in this report includes stands containing less than 10 per cent of normal stocking in addition to those stands which have started within the period of a normal age class.

Heavy cutting of the original forest will result in stands essentially even aged. The exceptions to this are stands which have little merchantable timber or which have so definite an all-aged character that partial cutting is most practical.

### III.

### Definition of Empirical and Normal Yield Tables

Chapman's Forest Mensuration pp. 395-397 gives definitions of empirical and normal yield tables, which concept is agreed to by this committee. We wish particularly to emphasize that what we conceive to be normal or index yield tables for American conditions will show the growth that may be expected from present well-stocked immature stands. They will not necessarily indicate the full potential productive capacity of the land as European tables do for planted and thinned stands.

IV.

Major Uses of Tables Such as May be Prepared

1. To determine best rotation age for management purposes.

2. To determine permanent sustained annual yield for long-time prediction.

3. To have data for private owners as to the probable yields from practicing forestry.

4. To make scientific comparison of regions, sites, and species.

5. For short-term prediction of the immediate yields from existing immature stands.

6. For appraising immature timber.

V.

The Application of Yield Tables - Both Normal and Empirical

Considering the above uses of yield tables, normal tables only are suitable for uses 1, 2, and 4, but may be used with proper correction factors very readily for uses 3, 5, and 6. Empirical tables are adapted only to uses 3, 5, and 6, and then only on the specific tract for which they are made. Empirical tables are "experience tables" and are not based on the laws governing natural conditions, but on the assumption that the stand, which will mature in the future on a certain area will be a duplicate of stands which have developed in the past. By their very definition they are proper only for local and short-time prediction and therefore have no use in research mensuration.

All tables which are made hereafter by the Forest Service should conform to the above conception of normal tables, except when a table for immediate and local use is needed for a tract for which no normal table is available, in which case the making of a so-called empirical table is justified.

VI.

Broad Plan for Making Yield Tables

It is the feeling of the committee that the preparation of all normal yield tables should be strictly a function of Research, at least to the extent of specifying standards, methods and procedure, and correlating results, and ordinarily to the full extent of doing the field and office work. The preparation of empirical tables may or may not be done by the administrative organization; it may often be convenient to do it in conjunction with timber surveys.

It should also be the function of Research to make office and field investigations looking to the perfection and standardization of methods of making normal yield tables.

The details of yield table construction are being considered by the committee on Standardization of Yield Tables. We wish to suggest that the method of selecting plots described by Chapman (Forest Mensuration p. 397) fits in with our concept of normal tables. We also feel that plots measured for yield tables will ordinarily be temporary but we urge that when convenient such plots be marked and described so that they might be found a decade hence. We also emphasize the need of a "skeleton system" of permanent plots as a means of checking and supplementing yield tables.

## VII.

## Site Classification

This committee is in agreement that total height should be made the basis of site classification, in accordance with the general recommendation of Sparhawk's committee. We urge that the Committee on Yield Table Standards, in conference with the Branch of Research, prepare standards for the age basis of height measurements for purposes of site classification, a standard number of sites and their unit basis for difference, and a system of coordination between regions. The same agencies should decide upon the policy of subclassifying sites according to mixtures of species, etc.

## VIII.

## Determination of Correction Factor With Which to Apply Normal Tables to Actual Conditions

As is generally recognized, in applying normal tables to <u>existing</u> immature stands a correction factor must be introduced to allow for abnormal gaps in the stocking and to allow for differences between full scale and probable actual utilization. These correction factors will usually be obtained and applied by the administrative organization or the one making the management plan or the growth prediction. But it is entirely proper and often advisable for the research organization to determine these reduction factors at the time the growth study is being made. Thus the collection of empirical data would go hand in hand with normal yield table preparation. Such correction factors are of greatest dependence and greatest need only in stands which are approaching maturity.

We consider it important that all normal tables show the basis that defines their normality for each age and site whether it be range in number of dominant and codominant trees per acre, basal area or volume, that it will be possible for the administrative forester to determine the departure of the actual stands he has from the normal and to apply the right correction factor.

Thornton T. Munger, Ch.
E. F. McCarthy
Willard R. Hines
Elers Koch
Duncan Dunning
C. E. Behre.

Review of Report of Site Classification Committee
Society of American Foresters
E. N. Munns

Object of classification

Definition of site, objects to be attained, need for further consideration

Present practice

General usage

Prediction of yields

Amount of wood produced, treatment of stand, species composition, age.

Only sound basis for classification is potential volume production of stand; necessary to assume, culmination of growth, definite treatment, even age.

Designation of sites: 1-5 not enough with wide range of conditions.

Site indicators: height growth, vegetation, soil analyses, existing stands, form, volume growth.

Height the best and most reliable index.

Need for height growth indicators

Tables of yield, height growth and age.

Recommendations

Some method needed now.
Height growth should be used as basis.
A permanent site committee of the stations or of the the Society of American Foresters is necessary.

Mr. Korstian - Endorses Munns' suggestions that a new, permanent Forest Service committee be appointed to consider the classification of sites.

## Height as a Basis for Site Classification

E. H. Frothingham

### 1. Reasons for comprehensive site classification

Classification of forest lands in terms of productive capacity is a matter which foresters will have to handle on a large scale sooner or later. There is need for a method by which this can be done quickly, easily, and acceptably. A great advantage may be gained by adopting for the purpose a standard, or standards, which will be widely current among foresters and which will facilitate comparisons and bring out reasons for differences and similarities in yield between separate regions.

### 2. Essentials of an ideal comprehensive system

Essentials of an ideal, comprehensive site classification system include: (a) reliability; (b) simplicity; (c) elasticity; and (d) applicability to all regions, species, and stands, without reference to degree of stocking.

### 3. Height as an index of site

Height of dominant trees at a stated age or at "height-growth maturity" is proposed as a standard basis of site classification. The novelty of the proposal is not in the principle of height as a measure of site, which has long been recognized and used here, as in Europe, but in the effort to systematize, so that the age-height relation and contingent volume relation of closed stands may be universally intelligible.

### 4. Consideration of height as a site index

(a) It is not the true final measure of site, which is volume, best expressed as current annual volume increment.

(b) It is, however, the most site-sensitive of the main factors of yield.

(c) Volume units as measures of site are restricted in use to well-stocked stands, are hardly applicable outside of pure, even-aged, or managed stands, and hence are excluded for extensive use. Their use would involve stand tallies and computation, even if such regular stands could always be found.

(d) Height cannot, of course, be used where there are no trees. Other methods, such as analogy from plant indicators, measurement of physical factors (provided undebatable standards can be provided), or mere ocular comparison with sites of known quality, appear the only alternatives.

(e) Since height-growth is sensitive to forest influences and inherent tendencies, care and judgment are necessary in choice of trees for index; but this objection is not very important except for precise determinations beyond present needs. As knowledge of growth laws increases, refinement of site determination by height can be increased.

(f) Height as an index is simple, natural, easily understood, easily applied.

(g) Sites thus determined are species sites, not permanent type sites; hence they are useful for either short-lived intolerant or long-lived tolerant species on identical land.

(h) By adopting one or more index species (intolerant species of wide occurrence on a variety of sites) the height growth of other species can be gauged, their relative value in each site can be determined, and this value can be expressed by naming the site in terms of the growth of each species present.

(i) Affords means of comparing growth of all American species on basis of soil and climate to which each is best suited, as well as in less favorable sites.

(j) Permits ready comparison (a) between even-aged second-growth stands in widely separate regions, thereby avoiding such inconsistencies as those to be found in the published yield tables for the same species in different States, and (b) between second-growth and old-growth stands in the same or different regions.

(k) The simplicity of the height method recommends it as expedient at this time when we are beginning forestry over large areas with no better basis for site determination adopted or in prospect. Standardization is the next step ahead.

(l) In connection with species height growth curves this method can be used with substantial accuracy for all ages after the juvenile stage.

5. Professor Roth's classification scheme

(See Forestry Quarterly 14:3, 1916, and Journal of Forestry 19:374, 1921.)

6. Application of Roth's scheme in studies of jack pine and southern white cedar.

7. Height method in use in the Southern Appalachians

A uniform height interval at 100 years, supplemented by height-age curves.

8. Are height-age curves distorted by drawing through arbitrary points at a given age?

Latitude allowed for consistent accuracy. Latitude allowable for insufficiency of data.

9. How will a comprehensive standard site system affect existing site classifications?

Sites are now pretty generally tied up with yield tables. The proposed system will enable recognition of sites for which there are no yield tables at present. Readjustment of yield tables to conform to extended series of sites will therefore be necessary.

10. Field use of height-age method in classifying sites, and applying yield tables.

Discussion of application of yield tables for southern upland hardwoods. (See Journal of Forestry 19:1, 1921.)

11. Steps necessary to put a height system of site classification into effect in the United States.

A coordinating board in the Forest Service to cooperate with other agencies through the Society of American Foresters.

Brown - Study of southern pines employed sample dominant tree for showing the height growth and site on each plot. Did not use height of trees at various ages as found standing at the time of study.

Forbes - Does this method apply to sprout or coppice forests as well as seedling?

Frothingham - Yes.

Show - This plan of site classification found to be only workable method so far in California. Determinations of height at 50 years generally reliable as index of site.

System of site classification should be uniform throughout the range of a species.

Koch - Is it the intention to have a site classification which applies throughout the entire country for all species so that site I is site I everywhere and anywhere?

Frothingham - Species can be classified or standardized for the entire country. For instance, yellow poplar and western white pine might both fall in the "Standard A" class, but a site I for western white pine might not be site I for yellow poplar. A site I for white pine should always be the same throughout the range of white pine, however.

Zon - This system is intended merely as a means of classifying present and existing forests?

Frothingham - Yes.

McCarthy - Is there, in the opinion of those here, any better indicator of site than height?

(No answer)

Behre - Density of stands seems to interfere with use of this method, especially northeastern spruce.

Frothingham - Method seems to work best for intolerant species, poorest for tolerant species especially when there are no mature or nearly mature trees available for analysis.

Weidman - Has attempt been made to classify species into standards A, B, C, etc., as suggested?

Frothingham - Not yet. That is what we want to start. The committee proposed by Munns should begin that work.

Zon - The height varies with management as well as with site conditions.

Kittredge - Brown's suggestion seems best, that we should follow actual trend of height growth and not arbitrarily fix any two points to govern the different site class curves.

Clapp - The committee in the society is not inclined to exclude other indicatiors or factors, is it?

Munns - Not at all. Height has been found best; that is all.

## Correlation of Types and Sites

C. Edward Behre

1. Statement of problem requires definition of type and site.
   - (a) Site refers to physical condition of area alone.
   - (b) Type includes both habitat and composition.
   - (c) From scientific and permanent management viewpoint the fundamental definition of type, emphasizing physical conditions, is gaining prominence. On this basis it is difficult to differentiate "site" and "type."

(d) Sites usually thought of as physical subdivisions of a type and it is in the correlation of different sites found in different types that I take it we are chiefly concerned.

2. Succession as basis for correlation.

(a) Shows interrelation of site and type as cause and effect.
(b) Furnishes a natural basis for type and site classification.
(c) Has great indicator value.
(d) Serves to correlate types and sites in stages of development of the climax, but does not afford a basis for distinguishing difference in site within broad climax communities as the western yellow pine type, and fails to correlate sites in one successional series with those in another.

3. Plant Indicators as Basis for Correlation.

(a) Plants are a measure of the conditions under which they grow and may be used to show differences in sites as well as types.
(b) Indicator method becomes refined and difficult if used to correlate types and sites.
(c) Large available indicator knowledge needs to be organized and tied specifically to physical conditions.
(d) Indicators may supplement and overcome limitations in study of succession.
(e) Phenological studies may supplement indicators to distinguish and correlate variations in types and sites.
(f) Indicator basis requires detailed taxonomic and physiological knowledge not only for its development but for its application. Average forester in practice would find himself deficient in these lines for best use of indicator values.

4. Soil Survey Basis for Correlation.

Correlation of soil types with best use of land may help in correlation between forest sites and types. "Land Use Survey" by Connecticut Agricultural Experiment Station.

5. Growth Basis for Correlation.

(a) Height Growth the most satisfactory and commonly used indicator of sites.
(b) Height growth may also express correlation between sites in different types by adoption of standards.

(1) Roth's triple standard for total heights attained at 100 years.

(2) Frothingham suggests referring height growth of all species to that of a few selected species of wide occurrence as indexes.

(c) Could not a simple workable correlation between sites in various types be worked out by expressing relative heights rather than absolute heights and referring all species in all types to a common relative index?

(1) Correlation based on height at fixed age.

(2) Express height attained by any species at fixed age on different sites as percentage of height on a particular site chosen as origin. Combining all species in this way will give a single index curve of relative height on site quality.

(3) Determine actual height attained by each species at the fixed age on the site chosen as origin. Two or more such tables tied together by overlapping species would probably be needed to reference all species.

(4) Sites would thus be designated as uniform divisions of physical conditions, but it should not be necessary to actually measure these conditions to establish the relative index curve.

(5) Application same as recommended by society committee except basis for height growth curves would not be arbitrary uniform divisions of height at given age for all species, but heights attained at that age on different sites as read from the index curve.

(6) Difficulty lies in determining whether given change in physical conditions gives rise to similar relative change in height growth of the different species, and in giving each species proper place and spread in the index curve.

Pearson - Ground cover found not suitable as index of site classification in D-3 because of fact that herbaceous vegetation seems to extend over a wider range than the tree species. Also herbaceous vegetation has been badly injured by excessive grazing.

## Effects of Soils on Site Qualities

C. G. Bates

The importance of soils as a factor in the growth of timber crops has been greatly underrated, due, no doubt, to the obscure nature of the differences between soils. It is not necessary to analyze these differences to understand their import. It is only necessary to show that tree growth is very sensitive to such differences. Within any region

which an individual forester is likely to study intensively, climatic differences, except those resulting from great differences in altitude, may be largely ignored; the differences which give rise to site differentiation are then those of slope, exposure and soil. It appears, at least in the Rocky Mountain region where there is a great variety of geological formations, that soils produce singly the greatest differences in site.

1. A measure of the importance of the soil factor is seen in the statement that with all other conditions equal, a sensitive species like lodgepole pine may vary in growth from complete failure on a limestone soil to a value of unity on a granitic soil and a value of 1.86 on a favorable gneiss, while a soil-tolerant species like Douglas fir varies through a much smaller range. Within a given soil type factors such as slope, drainage and deposition may alter its productivity by almost as great proportions.

2. Various species differently affected: Not only is the relative value of a given soil different for different species, but certain soils which are very stimulating to one or more species may be very depressing to another species or group. Throughout our tests there seems to be a fair parallelism between the likes and dislikes of lodgepole and yellow pines, but these usually respond very differently from spruce and Douglas fir.

From this statement it will be seen that soil preference should and is likely to determine what species in a mixed stand should be favored. In the present discussion the point is that a given site is Quality I or II or III only for a given species. It may be something radically different when the growth of other species is considered.

Half a dozen pots of sand had clay added to them in amounts of 10, 20, 40 and 80% of the volume. Increasing amounts of clay up to 40% had a beneficial effect upon yellow pine and lodgepole pine but a depressing effect upon spruce and Douglas fir. Very fine granitic sand added to the same base depressed the yellow pine and fir while stimulating lodgepole and spruce. The strangest thing is that while spruce does not avoid heavy clay soils, this particular pure sand was very favorable to it. There is no evidence at all that these effects are due to mechanical qualities of the soils. It is purely a question of the chemical preferences of each species.

Various other tests could be cited which show a general antagonism between the pines and the spruce and fir.

3. Effects of soils on root development: Generally speaking, rooting vigor is a very good criterion of the vigor of the whole plant and of the extent to which its growing needs are being satisfied, so that we should expect any soil which produces good growth to show good root development. This is by all odds the most general rule, but there are some striking exceptions.

A series of nitrate additions to a sand soil curtailed root development of both Douglas fir and yellow pine, and curtailed weight accretion by almost exactly the same percentages. With the further addition of magnesium yellow pine was equally increased in root development and weight, while Douglas fir was fatally inhibited. Many other parallel tests might be cited in which general vigor is closely reflected in root length. Exceptions are found in the case of a glaciated granite soil where the subsoil was for yellow pine 23 per cent less stimulating than the surface soil, but the former produced 27 per cent longer roots; a prarie clay of very stiff texture was slightly deficient in nutrients for Douglas fir, but caused root development 40 per cent above the standard.

If there is any one thing proven by the observations on roots, it is that the mechanical properties of the soil have practically nothing to do with their development. If the vigor of the plant is not seriously impaired by a chemically unfavorable soil, it appears that the roots tend to grow toward that region in which the most favorable condition may be found as affected by total moisture, aeration, etc., reacting upon the soil nutrients.

4. What constitutes a favorable soil? This is an extremely difficult question to answer without getting into deep complications. We can by simple laboratory tests, however, determine the productivity of any given soil with any given amount of water. If within any reasonable limits of moisture the soil produces strong seedlings, it is very certain that its chemical nature is favorable to the given species and that that species will be a high producer on the soil. If the soil produces well only when excessively watered, there will be indicated a checmical antagonism and a serious barrier to the reproduction of the species, while if the soil produces best in a decidedly dry condition it is one which may give heavy reproduction but relatively poor growth because of a deficiency in nutrients.

From this a method for the selection of the best species and a comparative rating of the soil for that species may be tentatively suggested. If, within any locality having a common geological soil origin (for example, an area of granite or sandstone or limestone) a given species is found widely distributed (for example, both on ridges and in bottoms) that is all that is needed as an indication of a favorable chemical relation between the species and the soil, and it is probable that the species which has this wide distribution is one which will make the best use of the soil type. Whether or not the soil type will be a high producer, relative to other soil types, may then best be determined by considering its weight, or by an actual leaching test which will show its relative fertility. The heavier the soil, if of favorable chemical composition, the more likely it is to contain abundant nutrients for sustained growth.

This paper is not designed to offer a solution of the soil problem, which is far from being solved in the writer's mind, but to point out some of the striking effects on growth resulting from different

chemical properties of soils in order to demonstrate that situation alone is not the most important element in site.

While it is known that in a certain sense the conifers, which have been studied, are more sensitive than hardwoods to slight soil differences, it is questioned whether the problem is really less serious in the hardwood forests, in view of their greater <u>demands</u> for nutrients.

(Bates' paper was illustrated by curves and photos.)

<u>Pearson</u> - Topography found to exert noticeable influence on height growth.

<u>Dana</u> - Does not a cutting exert an effect on and tend to produce a change in site conditions? How are you going to determine the site after cutting?

<u>Frothingham</u> - It does. Second question to be brought up later.

<u>Munns</u> - Many difficulties exist in this system, but the fact remains that this is the best useable system which fills the present need.

## <u>Application of Yield Tables in Southern Pine</u>
R. D. Forbes, Director

1. Will yield tables be applied at all to stands already established, or will their use be confined to exposition of potentialities of land for timber growing?

   a. If latter, is any warning necessary against applying yields to large as well as small areas?

      (1) Extent to which systematic protection is likely to result in "normal" stands everywhere.

2. Possible application of yield tables to actual stands.

   a. Estimate of present volume of stands now under or overstocked.

      (1) Use of tables justified only in rough estimates, very poor substitute for actual cruise.

   b. Prediction of future yields from stands now under or overstocked.

(1) Success depends on skill in application.

(a) Decidedly not a layman's job, and to attempt popular exposition probably a waste of time.

(b) Not a job for every forester.

(2) Possible bases for application.

(a) Present number of trees. Poor, both in theory and practice.

(b) Present number of dominants. Most hopeful basis, but would not use of current growth figures be more accurate?

(c) Present basal area. Academic conception no simpler to calculate than volume, and open to same objection.

(d) Present volume. Unsound, because it ignores future mortality.

Forbes - Discussed the yield tables prepared for souther pine and states that he had difficulty in applying these in the Coastal Plain region. Existing stands do not usually reach a density designated in the tables, and that discount percentages are needed for use by the timber owners in applying the tables. Some table of discounts should be provided.

While an attempt was made to approach normality in the construction of yield tables for southern pines, it has been found necessary to go back to the field to gather empirical data, since it is necessary to predict average growth to create an interest in timber growing.

The total number of trees per acre was found to be a satisfactory basis for the application of yield tables. The data obtained show that normal and empirical plots cannot be distinguished ocularly in the field. Some stands are so opened that prediction can be made only by a cruise, and application of growth of individual trees.

Tiemann - What is a normal plot?

Forbes - Plots of not less than a certain crown density up to complete crown cover. Since plot density cannot be judged, the idea of normal plot does not work. I can't see that we can go any farther.

Clapp - Have you given up?

Forbes - Yes. If we can't determine it as foresters, Lord help us if we try to tell anyone else.

Hine - The number of trees was too high on plots at first, since the best stands were measured. Later we selected plots of best growth on areas, regardless of density.

Brown - Plots were rejected merely by inspection in field. If basal area showed four times standard deviation the plots were rejected. Again we eliminated plots by position on curve. Each height class and age class were considered separately.

Dunning - Were other factors than basal area considered?

Brown - Yes.

Forbes - Can yield tables be explained to laymen?

Frothingham - I maintain that crown density for given species should be used.

Munns - Density of stocking, degree of suppression, amount and character of herbaceous material was used - also judgment.

McCarthy - Were pure stands used?

Forbes - Yes, those essentially pure.

McCarthy - Crown length is an indication of stocking.

Forbes - What is the effect of over or understocking?

Zon - Overstocking is more serious on good sites.

Clapp - Mr. Zon, what should be done - Give it up or not?

Zon - Should not be given up too soon.

Munns - More analysis of stands and data necessary. Additional field work is a prime requisite.

Clapp - Shall we give out present results but continue the work?

Zon - This is the first concerted attempt to collect yield data, and we are under an obligation to produce good scientific work for the National Research Council.

Munns - As well as for the Forest Service.

Koch - Why was basal area used rather than number of trees?

Forbes - Easier to get number of trees but cannot predict yield, since stocking relation is uncertain.

Clapp - Any reason for stopping this work now?

Munger - Range of number of trees in normal plots is too great.

Zon - Work up data by States.

Munns - Too many variables are involved, and too many people working independently were employed. Conditions of personnel as well as conditions of site, species and degrees of stocking renders the task a formidable one. Our biggest trouble appears to be an attempt to use uncorrelated data. My feeling is to extend the field work. This is the first time that different species growing in the same region, some on similar sites, some in mixture, have been worked up on the same basis and on the same units, by the same men. In our other work there was nothing to compare the data with.

## Application of Normal Yield Tables on the National Forests

Elers Koch

I have been of the opinion that for the time being empirical yield tables, which can be used directly without a reduction factor, will be better suited to the rather extensive work of our first management plans than normal yield tables.

I will have to admit at the start that my knowledge of the use of normal yield tables is entirely theoretical and book knowledge. I have never used normal yield tables in the preparation of management plans, because in the first place we have not had the normal yield tables, and in the second place, if we did have them, the data necessary to apply them to the actual stands were not available.

Consequently, my contribution must be in the nature of stating what the size and difficulties of the problems are rather than a solution based on experience.

I am going to put up the Coeur d'Alene management plan as a specific example. The stands involved are practically all even-aged in the white pine, larch fir or lodgepole types. The rotation is 120 years for all types. The distribution of age classes of all types follows:

| | | |
|---|---|---|
| 0 - 20 | 173,000 | acres |
| 20 - 40 | 61,000 | " |
| 40 - 60 | 13,000 | " |
| 60 - 80 | 54,000 | " |
| 80 -100 | 34,000 | " |
| 100 -120 | 20,000 | " |
| 120 + | 190,000 | " |
| Total ........ | 545,000 | " |

The method of figuring the annual cut was a simple volume and area allotment method, in which the yield of each age class is predicted at the rotation age, and the annual cut was determined by trial to determine the largest amount which could be cut from present mature timber and from the yield from each successive age class without any gap in the available supply through the first rotation.

The essential to the accuracy of this calculation is, of course, the prediction of yield of each age class when it reaches the rotation age. In the preparation of the Coeur d'Alene management plan empirical yield tables were used, based on yield plots taken by the regular timber survey crews. The accuracy of these tables is doubtful on account of the not too careful determination of ages in taking the plots by the timber survey crews, but assuming that satisfactory empirical yield tables are available, the simplicity of the method commends it. No data are necessary on the age classes under the rotation age except the area of each type and age class.

Now, assuming normal rather than empirical yield tables were to be used in this case, what processes are necessary in order to apply the tables to the stands?

There are 355,000 acres of young stands under the rotation age, and it is obvious that any plan for dividing the area into site qualities and determining the variation from normal stocking is going to involve a lot of field work. The usual method for applying normal yield tables to a specific stand is, first, to subdivide into site classes, usually on the basis of height, and, second, to determine the degree of stocking as compared with the normal, generally through comparison of basal areas. This could not be done with any degree of accuracy with less than a 5 per cent cruise, which would cost from 6 to 8 cents per acre.

The yield of stands over 60 years old could probably be predicted fairly closely by this method. I am not sure, however, that the yield of the younger stands can be predicted much, if any, closer by this plan than by the use of empirical tables at much less cost. There is considerable doubt whether final yield is at all proportionate to basal area in young stands, and also whether any other unit of measure, such as number of trees per acre or volume in cubic feet, will give a constant basis for reduction.

In the selection of plots for normal yield tables, who can say whether in the 30-year age class a stocking 8,000 to the acre or 800 will give the higher final yield? Certainly at that age neither basal area nor number of trees to the acre, nor cubic foot volume will afford a basis for reducing the normal yield table.

My conclusion is that for young stands, say less than half the rotation age, the use of normal yield tables is subject to such great opportunity for error and requires so much guess work in application, that the expense of a detailed cruise to establish a basis of comparison with normal tables would rarely be justified. Broad average yield figures based on empirical tables would be just as accurate and much less expensive in application.

For stands in the latter half of the rotation, the possibilities of accurate prediction of yield through normal yield tables are much greater, and, of course, the shorter time will elapse before an immature stand is cut, the greater the necessity for accurate yield prediction. For instance, the St. Joe Forest has a very large percentage of the area in the 80 to 100-year age class. This timber will be cut in from 20 to 40 years, and we will probably not be satisfied with our yield calculations until we have made at least a 5 per cent cruise of these areas, subdivided them into site qualities, and determined the basal area or volume for calculating their yield by means of normal tables.

Show - How much do site qualities vary in white pine?

Koch - Not great range in white pine sites.

Weidman - Compilation of data not completed.

Dunning - Division of forest by site as well as by type necessary in applying yield table.

Koch - Not possible without more data than now secured.

McCarthy - Are log lengths secured in cruising and are sites divided based on them?

Koch - Sites would only divide types - not done.

Weidman - Cannot recognize site but plots are taken by selection and sites will be determined by productivity afterwards.

Clapp - How are sites classified in D-6?

Hofmann - Sites are based mostly on elevation in Douglas fir region.

Munger - Not difficult to divide sites in region by using height as general indicator.

Clapp - Do reconnaissance crews get sufficient data for site classification?

Munger - No.

Clapp - Can it be done?

Munger - Most surveys are in mature timber.

Forbes - Do you know area of type?

Koch - Only in large divisions.

## Methods Used in Europe for the Application of Normal Yield Tables
J. Kittredge, Jr.

One German definition of normal yield: "The yield on an area on which all the local factors of wood production have expressed themselves unhampered in the annual production of fiber." Fifteen per cent variation in basal area or volume allowable for stands to be considered normal.

Even in Germany the average stand lacks 25 per cent of being normal.

Separate tables are made for different site qualities, usually 3 or 5.

The tables are ordinarily used only for predictions 10 or 20 years in advance which limits the range of inaccuracy which might result from their use for longer periods.

European tables are based on and applied to pure even-aged stands.

They include separate figures for intermediate yields from thinnings; thus obviating two possible difficulties in the make-up and application of tables in United States, namely, (1) the possibility that we are including in our tables yields of overstocked stands which have an abnormally large number of trees to the acre and have stagnated in growth as a result; and (2) the fact pointed out by Carter for white pine in Massachusetts that stands with widely different numbers of trees to the acre at 20 or 30 years may give equally good yields at 50 years.

Yield tables for pure stands cannot be applied to mixed stands of same species, because it has been shown that in general, and specifically in the cases of pine-spruce, pine-beech, and oak-beech, the mixed stands yield higher, sometimes as much as one-third higher, than either species in pure stand.

The application of yield tables involves determination of (1) age, (2) site quality, and (3) stocking. Age is easily ascertained.

Site quality is determined.

(1) By use of average height at given age as index. Fricke even states that stands of same heights at 100 years have the same heights at other ages and that; therefore, the same yield table based on the height relations can be applied to stands of a given species throughout the whole range of climatic conditions in which it occurs.

(2) By use of volume per acre of one or more sample plots in the stand to be studied and assuming, or having ascertained that it is normally stocked, the present volume of the sample corresponds with the normal yield table volume at the same age for the proper site. This involves a preliminary determination of degree of stocking.

(3) By the Russian formula method (or use of a site factor) by which F or the site factor equals H (height of average tree) times BA per acre divided by N, the average age of the stand ($F = \frac{H \times BA}{N}$).

Samples of stands to be studied are measured to determine average height, basal area and age and the factor worked out and compared with factors of normal tables.

Degree of stocking or density is determined:

(1) By estimating ocularly the deficiency in the growing stock (crown density).

(2) By comparison of volume of sample plot or plots with normal yield at same age for same site.

(3) By comparison of basal area per acre of sample with normal basal area for same age, height and site, assuming that volumes of even-aged stands under these conditions vary as their basal areas.

(4) By use of Russian "density factor," which equals average height times basal area divided by average diameter ($\frac{h \times BA}{d}$), which is then compared with corresponding density factor for normal stand.

In predicting future yields of understocked stands, all of these methods imply a comparison of present conditions with the normal of same age and assume that future development will be in same ratio to the normal.

Schenck said, "Normal yield tables are of little use in American forestry."

In France, yield tables are not used. Exactness in yield data is considered unimportant if there is frequent stock taking and good silviculture. They compare inventories by size classes at 20-year intervals with empirical well-stocked composition by means of graphic charts. Use growth per cent or time to grow from one d.b.h. class to next to determine increment. Yield and growth figures are simply the result of repeated experiences in harvesting the forest crop. These methods give good results without necessity of time and expense of preparing yield tables and applying them.

Clapp - What is best method you suggest?

Kittredge - Same as French scheme. Predict size classes as well as possible.

Density of stocking most important factor.

Zon - Different perspective in Europe. The yield tables are no longer needed. Cannot use normal tables but must know conditions.

Gisborne - French foresters use tables to show species ages, production, etc.

Brown - Chapman allows 25 per cent variation in tables.

Clapp - Methods of application are part of the job of Research assisted by Forest Management. It will be up to the experiment stations to work out the application of the methods used.

## Volume Tables with Special Reference to Growth and Yield Studies

Duncan Dunning

In scientific studies of growth and yield, volume tables should give true expression of form and tree contents.

I. Uniformity of Tables Desirable to Enable Comparison between Species and Regions

1. Universal tables for all species based on Tor Jonson method not yet possible.

   a. Extremes of size and age classes of American species.

   b. Extremes of bark thickness and root swelling in larger species.

c. Extremes of site within range of species.

d. Single table based on taper formula probably will give reasonably accurate results for one species under all conditions where extremes of size, age and site not great.

e. Application of Swedish methods to American trees. Claughton-Wallin and McVickar, Wickenden, Wright, Behre.

2. Taper curves for each species by sites and age groupings based on appropriate taper formulae offer most hope.

3. Fundamental studies of laws of taper, bark thickness and root swelling needed. Few suitable measurements now available for western species. Slow and expensive process.

4. Present regional study of western yellow pine data a short cut method to simplified tables for immediate practical application with present standards of utilization.

5. Possibly standard site class tables for young and mature timber will replace many local tables.

6. Wide application of single table presupposes make-up of stands similar to that on which table based, as well as similarity of form, assuming that taper curve changes with age.

7. Use of local tables for each sample plot.

8. Changing tables as age of plot increases.

9. Use of sample tree method instead of volume tables.

II. Units of Measure

1. For scientific studies cubic foot tables preferable.

a. Applicable to small sizes, avoiding some of apparent sudden increases due to growth of trees into lower size limits.

b. More even progression and better indication of small changes.

c. Ratio of given contents to true volume of tree changes less with size than for board measure.

d. Method of construction fairly similar between regions.

e. For future yields more adaptable to increasing intensity of utilization.

2. Board foot tables for commercial studies.

a. Supplement cubic foot tables for calculation of financial returns from expected yields.

b. Board measure more generally understood.

c. Calculation in board feet need not be extremely accurate or detailed, thus saving in expense of compilation. Use of board foot - cubic foot ratios.

d. Possibility of change from board measure to more scientific unit of measure slight.

e. Closer utilization and increasing value of products require more accurate tables. Use of more scientific log rules. International Rule, 3/16 inch kerf, for growth and yield - particularly in second growth.

III. Construction of Tables

1. New field measurements should be taken so that data are suitable for fundamental studies of taper, bark thickness and root swelling.

2. Grouping of data for site class tables. Preliminary, on basis of height. Final, by comparison of heights, form factors and form quotients.

3. Sampling large groups of data.

4. Taper curving.

5. Choice of log rule.

6. Scaling practice; stump height, top limit, log lengths, trimming allowance. Total height or merchantable height.

7. Form factor method or conventional method.

8. Uniformity in method of calculating frustum form factors and base tables.

9. Characteristic species form factor curves. Harmonized site curves.

10. Attempts to use parbolic and conic form factors for total height tables.

11. Data which should appear in final table.

12. Checking.

IV. Use of Tables in Compilation of Sample Plot Data

1. Printed interpolated tables.
2. Curves and alignment graphs.

## Volume Tables: Growth and Yield Investigations

R. M. Brown

### Board Foot Rules in Practice Unsatisfactory

Desirability of use of sound mathematical board foot rule as basis for all reliable tables. Most board rules in use not sufficiently accurate under present standards of utilization.

### Cubic Foot the Standard Unit of Measure

Use of cubic foot measure desirable in general practice. Can be applied and used as a universal unit of measure under all conditions of growth and utilization. Not affected by varying commercial practices. Can be used in stands where branchwood is important.

### Cords as a Unit

Need of more reliable information necessary for converting factors. Further investigations needed of actual cubic feet of wood in cords stacked from trees of different sizes in young stands. Desirability of expressing branchwood in cords in volume tables.

### Converting Factors

Need for reliable factors. Difference between factors based on economic considerations and those of mensuration. Which should govern the adoption of factors in our current work?

### Utilization Standards

1. Cubic feet - total vs. merchantable. Portion of trees to be used in volume table construction in each. Stump, top, bark, etc.

2. What should constitute upper diameter limit of top and need for further investigations? Variable vs. constant top diameter limit.

3. Total height or log lengths, in hardwood volume tables.

4. Should yield tables of total volume include all material present or only to a fixed diameter limit? What should this limit be?

5. What should be done with inferior species in almost pure stands? should actual volume of all trees be obtained, or should volume of a substitute tree of same size be included, or should volume of inferior trees be rejected in field tally?

Hensen - The local log rule should be used, such as Scribner in the Lake States. As a check, cubic volume be used.

Dunning - International rule can be introduced in the various regions.

Forbes - Why not use the cubic meter?

Zon - Do you realize that there has been an effort for 25 years or more to introduce the metric system and that it has not yet been able to overcome local usage of foot and inches?

Munger - We should continue present use of local log rule and use cubic foot as a check.

Frothingham - In addition International rule should be used.

Munns - All log rules should be stsndardized to International rule. The sooner the better for all. Cubic foot should be used for all material including present unmerchantable; International for the merchantable.

Zon - Local log scale and cubic foot volume can be used if they have a good converting factor.

Koch - We should undertake standardization toward making International rule standard log rule.

Behre - (Explained in detail the form quotient method.)

Brown - Cord as a unit of measure should be given greater consideration with increase of importance of the pulpwood industry.

Better converting factors necessary from board feet to cubic feet.

In hardwood tables branchwood in cords should be included on account of their use for acidwood.

Weidman - In cubic volume tables, full volume of stems including stump should be made in view of changing stump height.

Munns - We should get rid of antiquated methods and get down to using a simple and readily understood rule, both in the Forest Service and elsewhere that will be fair to the seller as well as to the buyer. At the present time, the use of the Doyle in the southeast is manifestly unfair to the seller of timber - the small woodlot or timberland owner who will be most interested in the forestry of the near future. The Decimal C rule also has very little to commend it, though in the higher diameter classes it comes close to the actual cut. The small diameters are the ones we should watch at the present time. There can be no defense for any of the so-called commercial log rules and the sooner we can discard them the better.

Permanent vs. Temporary Plots in Growth and Yield Studies
G. A. Pearson

1. This is not a case of conflicting ideas.

   a. Each type of plot has its place, and place of each is usually well understood.

   b. Desirable to make all plots permanent as far as practical. Even the most temporary plots should be marked so that they can be relocated.

2. Permanent plots

   a. Growth studies by periodic measurement.

   b. Yield studies.

3. Temporary plots

   a. Stand surveys.

   b. Valuation surveys.

4. Number and size of plots required.

   a. Depends upon uniformity of stand and site.

   b. Depends upon size of area represented.

   c. Depends upon density of stand.
      Should be large enough to secure good representation of diameter classes; should not be so large as to preclude detailed work.

d. Many small plots vs. few large ones.

e. Should only one site quality be represented in a plot? If so, how are data to be applied to extensive area of mixed sites?

f. In the case of old plots representing mixed site qualities, how may sites be differentiated?

Clapp - Mr. Munger, what have you used in D-6 in your yield studies?

Munger - Temporary plots were used in the D-6 yield studies. It would have been desirable to have marked the plots permanently. D-6 plans to attempt to relocate some of these. It is very desirable to tag all trees in permanent sample plots.

Weidman - To make a normal yield table for even-aged stands it is desirable to use chiefly temporary plots.

Zon - Agrees that temporary plots are desirable for even-aged forests.

Kittredge - Pointed out that there are changes in the stand that can be studied only by means of permanent sample plots.

Munns - Permanent plots are essential in methods of cutting studies.

Weidman - There is a field for both classes of plots even in methods of cutting studies.

Pearson - It would be advisable to mark temporary plots. They can then be found easily and remeasured if found to be desirable.

Munns - Strip surveys could be marked at beginning and at intervals on the course run. These then become valuable for further examination.

Frothingham - The Appalachian Forest Experiment Station is using permanent plots for thinning and methods of cutting studies and temporary plots in yield studies.

Behre - Westveld is marking plots he is now putting out so that he can return to them if desirable. At the Northeastern Forest Experiment Station we believe it desirable to mark them.

Krauch - The big value of permanent plots is that the trees on them are tagged, while those on temporary plots are not tagged. This makes them less desirable for the purpose of remeasurement.

Korstian - Suggested that in the case of borings made to the center of the trees, they should be adjusted to the average radius.

## Field Technique in Growth and Yield Studies

Duncan Dunning

Field methods dependent on object of study and proposed office methods.

Permanent or temporary sample plots - advantages and disadvantages of each well known.

1. Urgent need of yield tables necessitates use of temporary sample plot method where fully stocked stands representing different ages by types and sites may be had. Should be supplemented and checked by permanent plots.

2. Studies of effects of cutting necessarily involve permanent plots. Temporary plots and timber inventories for timber sales administration.

### A. Permanent Plots

I. Planning Work

1. Location in relation to other work to avoid excessive travel.
2. Timing establishment to avoid periodic seasonal overloading with field and office work.
3. District research project map.
4. Note during travel suitable stands.
5. Limitation to concentration and synchronism, suitable stands, cutting operations, etc.
6. Brief working plans or field instructions listing details of work and equipment needed saves loss of time and improves quality of data. Use of forms.
7. For remeasurements field copy of previous notes, photographs and original measurements in convenient form.
8. Fractional parts of growing seasons.

II. Selection of Plots

1. Suitability of stand to object sought should be assured. Restriction of variable factors represented. Each plot should represent only one site, type and age class or cutting method.
2. Future accessibility.
3. Insuring permanency. Signing. Withdrawals.
4. Site and type standards.
5. For cutting plots essential to establish plot and make complete examination before cutting.

III. Area and Number of Plots Required

1. For yield studies determined by sites, types and age classes represented.
2. For cutting studies by sites, types and methods of cutting.

IV. Surveying, Marking Boundaries, Mapping

V. Measurements

1. Crew organization.
2. Tagging.
3. Diameters.
4. Heights and hypsometers.
5. New trees.
6. Details saving time and expense.
7. Notes, forms and standard abbreviations.
8. Photographs.
9. Form changes in second growth forests and mature stands.
10. Reproduction strip tallies on cut-over areas.

VI. Costs

B. Temporary Plots

I. Selection of Yield Plots

1. Site criteria, height growth, soil character, herbaceous and shrubby vegetation, general knowledge of precipitation.
2. Degree of stocking. Presence of undergrowth. Rate of growth. Health of stand.
3. Type standards in mixed stands.
4. Area and number of plots required.

II. Measurements

1. Crew of three men most efficient.
2. Location of boundaries in relation to crown spacing.
3. Survey.
4. Diameter and height measurements dependent on method of compilation – with site – height curves available only enough heights of dominant trees taken to reference plot to proper site.
5. Allowance of openings and unmerchantable species.
6. Total ages and breast height ages.
7. Taper measurements taken where opportunity offers to check volume tables and height curves.

III. Costs

Forbes - The question of the desirability of painting numbers on trees as compared with tagging was briefly discussed, emphasis being placed on the fact that vandals do not molest the painted numbers as much as the metal tags.

Pearson - Regardless of the number of trees per plot the upper diameter classes above 20 inches are inadequately represented. Krauch has suggested that large trees outside the plots be tagged.

Dunning - There would seem to be an inconsistency in the computation of sample plot yields from volume tables based wholly on diameter and which do not take into account changes in volume in the individual tree.

## The Place of Increment Borings in Growth and Yield Studies

Duncan Dunning

### General

Various uses of increment borings - age determinations, growth predictions, effects of thinnings, effects of fire, insect damage, weather, stem analyses. Limitations.

I. In Management Plan Work

1. Even-aged stand yield tables, preferable if available.
2. All-aged stands for prediction of yield at time of second cut.
   a. Use in connection with stand tables from reconnaissance data.
   b. Select old cut-over areas if any available.
   c. Select typical dominant trees.
   d. Proper representation of diameter classes and species in mixed stands requires large number of cores. Proportion number by species and diameter classes on basis of importance and representation in stand.
   e. Correct stand left after typical marking by average losses due to logging and slash disposal. Allowance for subsequent death. Trees entering lower limits.
   f. From series of inch class diameter growth curves determine diameters at given future period. Apply height - diameter curves and volume tables.

II. To Supplement Temporary Plots for Yield Studies

1. Scarcity of fully-stocked even-aged stands representing different age and site classes. Particularly good plots may be used for one or two younger and one or two older 10-year age classes.

2. Allowance for changes in composition.

III. <u>To Determine the Effects of Cutting</u>.

1. Selection and description of trees.
2. Extent of cutting.
3. Other factors influencing growth; entrance of undergrowth, weather.

IV. <u>Fire Damage, Insect Damage, Turpentining</u>

V. <u>Correlation with Weather Records</u>

VI. <u>Measurement of Cores</u>

<u>Behre</u> - Believes that increment borings can be used much more widely than they have been used in the past. He suggested that two measurements taken on opposite sides would add to the accuracy by adding the two and reducing to the average radius as suggested by Korstian.

<u>Bates</u> - Raised the question that probably the stimulated diameter growth after cutting is not held uniformly up the tree.

<u>Behre</u> - The important question is proportionate stimulation at different points on the stem as affecting the form of the tree. Studies in western white pine are not yet completed to show how this works out, but the indication is that there is little change after 15 to 18 years. I believe that increment borings at the middle of the stem should be taken as well as at breast height.

<u>Dunning</u> - At the stations where studies in form are in progress, measurements should be made at intervals up the stem from the ground. This would probably give a definite answer to the question. Climb the trees.

## Standard Forms for Growth and Yield Studies

G. A. Pearson

1. Underlying Principles in Standardization

a. Economy in printing.
This is really a secondary consideration.
b. Development of best methods.

c. Uniformity of Methods.
    (a) Insures continuity in case of personnel changes.
    (b) Comparability of data in various regions.

2. Limitations of Standardization

    a. Variation in local conditions.
    Number of species, range of diameters, density of stands, rate of growth.

    b. Difference in objectives.

    (a) These should be harmonized as far as possible.
    (b) Should agree on certain basic data.

    c. Standards should be sufficiently flexible to admit of necessary variations.

3. Forms for Study of Gorwth on Permanent Sample Plots (Mc).

    a. Discussion of Mc forms recently adopted.

4. Proposed Forms for Yield Study.

    a. Form proposed by Munns.
    (a) Accommodates too few species on page.
    (b) Range of diameters too small.
    This can be remedied by omitting numbers of diameter classes.
    (c) Placing descriptive notes at head of sheet uses up space needed for recording measurements, and does not provide adequate space for the notes.
    (d) Some object to using back of sheet for any class of data; others favor using it for descriptive notes only.

    b. Form proposed by Frothingham.
    (a) Provides for large number of species, but leaves inadequate space for crown classification.
    (b) Proposes placing most of descriptive notes and also a form for analysis of sample trees on back of sheet.

    c. Form proposed by Pearson.
    (a) Accommodates 4 or possibly 8 species.
    Does not meet requirements in hardwood region.
    (b) Leaves one-half of columns open to be filled in as needed for tallying or compilation.
    (c) Descriptive notes on back.

d. Probable solution.
   (a) Special form for hardwood regions.
   (b) Form for western regions should accommodate at least 4 species.
   (c) Most of descriptive notes can go on back.
   (d) Limited flexibility by leaving certain columns open.
   (e) Supplementary form for
      Analysis of increment cores
      Taper measurements
      Seedling analysis
      Sample tree analysis

Munns - The following comments have been made on the Methods of Cutting Summary forms. While it appears as if considerable work were required to maintain them in good shape, it is believed that as the years pass, they will serve the purpose and justify their existence. Most final criticisms are not essential.

FORM 1

District 5: Omit heading in column "Volume - cubic feet or basal area" in order to avoid crossing out items on the sheet and for possible other uses if desired. Suggests that every tenth line be ruled heavy.

Bates: Columns not wide enough for typewriting.
A column is desired preceding the d.b.h. column headed "Disposal" to record information as to whether a tree was marked, cut, or knocked down.

Forbes: Change last column to "Seed-bearing capacity" instead of "Height to the base of crown."

Lake States: Change "Height to ~~base~~ base of crown" to "Length of Crown." Change position from extreme right to between total height and volume columns. Provision should be made on the form for initialing.

Northeastern: No provision made for trees partially or wholly released after cutting which had no definite basis for crown class. Crown class column should be omitted as crown class is included under physical condition column.

Appalachian: The month in which the examination is made should be given in addition to the year. It is suggested for the physical notes in the large series of columns that the numbers 1, 2, 3, and so on, would be preferable to the letter symbols proposed. In view of the possible use of machine tabulating, it is wondered if we could not use the series running up as high as 10 for the various classes involved.

Priest River: Form 1 cannot be used on yield study plots because of the large number of trees involved. It is doubtful if the crown classification is practicable in any but certain restricted classes of work.

FORM 2

Lake States: Double columns at top should be omitted in order to provide for any class of use desired. Recommended that "gross" be used instead of "total" as otherwise there is frequent confusion in definition.

Fort Valley: Total increment should be defined. Total includes the net increment plus the volume of dead trees. (See Chapman's "Mensuration," page 324). Should be gross instead of total in order to avoid confusion as on Form 4.

District 5: Desires to have area and location of plots put on each individual sheet as needed constantly in working up data.

Northeastern: Desires to combine new trees on Forms 2 and 2a and provide for the summary of increment bottom of Form 4. This should be prepared so as to provide more space than is now afforded to include mean annual as well as periodic annual increment. The form is too crowded and too little space allowed for easy recording and study of data.

FORM 4

Fort Valley: Desires to change total increment into period net annual increment and annual increment into net annual increment.

COMMENT

It was suggested that members of the conference should take up with the members of the Forms Committee any changes they desired. Munns pointed out that this had been considered in more or less detail with individual members already. Logical changes have been made. It is now felt that the Mc forms are in final shape and will stand the test of field usage. Idea has been to make them suitable for all long time permanent records for Management plots where individual tree records were kept. The committee was continued. Pearson, chairman; Munns and Bates.

## Efficient Methods in Yield Studies; Short Cuts, Crew, Personnel

C. G. Bates

In his introductory statement to "Instructions for the Establishment and Measurement of Sample Plots, D-5" (October 1, 1923) Dunning states "There is no question but that careful attention to the many apparently trivial details will greatly increase the amount of work done in a day and produce better data, thereby simplifying office work."

There is no doubt as to the truth of this statement particularly the part which I have underscored. I have known these details to keep a crew very, very busy until dark, and even then the ground covered did not seem adequate.

But we must have the details. If we neglect them, our contemporaries and posterity will certainly have unkind things to say of us. What I am trying to say here is simply this; there may be efficiency and inefficiency in doing field work, but there is certainly no such thing as a short cut to accuracy. The shortest way to good results in this work is certainly a long way around. I am then, talking about efficient or inefficient work as judged by the results. It cannot be too often repeated that if the field work is precise, almost anything can be obtained from the data; if inaccurate, nothing of value.

Since Dunning has produced an exhaustive thesis on sample plot measurements, and I have outlined what I consider essentials in the D-2 Research Handbook, there is no need to go over the whole subject. I shall simply pick out from these discussions and from what little I know of the work elsewhere, a few points on which there is apparently room for difference of opinion.

In any study of growth and yield, whether it be on temporary or permanent plots or by strip surveys or what not, I think it must be generally conceded that we want to determine the total productive potentialities of the site, which may best be expressed as cubic foot increments. With this fundamental information, we may use almost any method for transposing these data into board-foot increments or current yields. Our management, to be worthy of the name, must aim to obtain a maximum possible percentage of the total increment. We set this up as a goal - possible increment 100 cu. ft., net yield per acre-annum not less than 90 cubic feet or 500 or 600 board feet, as the case may be.

With this as a thesis, let us lead to essentials:

1. On either permanent or temporary plots, the measurement of every tree of appreciable volume. If we ignore trees 3.5" D.B.H. and less, which are putting on even 10 per cent of the total increment of the stand, why strive for more than 90 per cent accuracy in any of the other measurements. A better basis is to measure every tree which has a D.B.H.

2. On permanent plots, every tree tagged with a permanent serial number. This is not so much for individual tree records, of which a fetish may easily be made, as to make sure that none are overlooked. The writer is prepared to say that there is no satisfactory substitute for the complete tagging. Tags are applied as the trees are approached, moving from side to side in a comparatively narrow strip, whose new boundary is constantly being defined by the tallier and observer, the other boundary by the trees already marked.

After a plot has been tagged, two men should go over it carefully, following the edges of each separate strip and looking toward its center to see that no trees have been overlooked.

It is far more important for future ease of measurements that the trees in a strip should be approached in a natural and logical order, than that the strips should be formally laid out in straight lines.

3. Diameters breast-high measured to nearest 0.1 inch at designated point on the stem. The point originally chosen should be for convenience with reference to limbs, swellings, etc., and may be a little above or below 4.5 feet, so long as it is designated. We have found it most convenient to designate the "breast-height" as just below the metal tag.

In the original field work, the tagger nails on the tag while the diameter man is holding the tape in position.

4. Height measurements on every tree seem superfluous. Every tenth standing tree should be adequate to represent the different height groups, and at the outset, if any cutting is being done, we prefer to obtain representative heights from felled trees. Let us remember that height growth is not an end in itself.

5. Far more important than individual tree heights is a volume table of strictly local application to the area in question, since form factor varies with site and stocking fully as much as height (relative to diameter). A standard of 50 trees for any plot or contiguous group of plots may be taken as the minimum for a volume table. This must be revised as the stand changes in character, necessitating the cutting of trees in surrounding stands if more thinning is not to be done in the plot.

For a strictly local table, volumes on D.B.H. only will usually suffice, since D.B.H. and height will vary together. If further division is necessary, as for height groups, other tables can probably be consulted to obtain the correct curving of the rather meager data.

Volumes cannot be applied satisfactorily to groups representing more than 0.5 inches range in diameters and preferably tables should show volumes for each 0.1 inch.

6. While there is no serious objection to a field sheet for each individual tree, we can see no use in much of this detailed record. The conditions of importance (health, form, etc.), vary with the locality and their proper designation can be worked out quickly on the ground. We believe a single sheet allowing lines for 20-25 trees, by serial number, and with space for 3 or 4 successive diameter measurement, and a wide column for "Height and Condition" is all that is needed.

7. In any study of methods of cutting or thinning, the original tally should be made before cutting and trees to be left should be tagged. This is essential in order to know what conditions prevailed which may influence later growth, but also to know how badly the cutting has been done. I sometimes fear that we are "kidding ourselves" as to the care with which Forest Service timber is cut.

8. One of the greatest essentials of sample plot work is a thorough check of the stand after cutting and as this frequently means a delay of a month to a year, we have here a strong reason for employing local Forest officers in the original work. This check is a comparatively simple matter and involves accounting for all of the numbered trees which were supposed to have been left.

9. As stated by Dunning, a crew of about 3 men seems best for work on permanent plots. On original work the 3-man crew can be divided into (1) tallier and observer, (2) diameter man, and (3) tagger. On remeasurement work the third man is not needed. Usually the most experienced and careful man of the crew should take the diameters. A great deal of difficulty has been experienced in getting precise diameter measurements, even with the diameter tape applied at fixed points. Either one man should make all of the measurements on a group of plots which are to be compared, or there should be a regular rotation between members of the crew. The latter seems preferable, on the basis that the average of three men's work will compare pretty well with the average of any other three in subsequent years.

10. There is usually serious question as to how large plots should be to obtain "accurate" growth data. We do not want to cover any more ground than is necessary to properly represent a given set of conditions. It is not necessary to answer this question arbitrarily. In a stand of irregular character and uneven growth conditions for the individual trees it is found that the standard deviation of growth of any individual tree, from the mean growth of all trees of the same 2-inch diameter group, 48% of the average growth. This means that 50 trees will give us an average figure for growth of the one group, accurate to within 5%, which it seems to me is the greatest error that should be allowable. One hundred trees will only reduce the error to 3 per cent. Of course this does not mean that we must have 50 trees for every 2-inch diameter group, for by careful curving with the higher and lower groups we may hope to "iron out" some of this probable error. But it seems that the most variable size group of the stand should be represented by trees of this number, that is, 25 to each inch class. This group will be the intermediate trees of the stand, or possibly the co-dominants, so far as I have observed, the dominant and suppressed trees having more definite status. The above possibly represents an extreme case of variability, but may be used as a guide.

## Minimum Requirements for Sample Plots

F. S. Baker (Read by C. B. Morse)

Sample plots which have been laid out to date in District 4 have been handled entirely by the old Research organization and established in conformity with the regular practices of Research, including the multitudinous observations which are required on the growth and width of the crown, its shape, health and all the notations that are expected to be made regarding the condition and form of the tree. Now Research is abandoned in this District. Perhaps representatives from some of the surrounding districts having experiment stations will come into our region, but in view of our reputed poverty of timber, it is hardly probable that they will spend much time with us establishing many new sample plots. Just the same, we need results from sample plots even in the management of our lowly timber. Alpine fir and limber pine are managed on the same principles as the lordly redwood. What to do! It is entirely out of the question for us, even with technically trained Forest Assistants, to tackle the establishment of sample plots in all their scientific intricateness. Either we have got to go without, or find something that is adaptable to organizations bereft of a research branch and without the time to put in sample plots measuring up to Research's standard. We think that probably other districts, even those which rejoice in the possession of experiment stations, would be benefited also by the formation of a standard plan for sample plots which would be useful for simple management purposes. Research intends to use the results of its plots as a basis for seeking out fundamental facts; as the correlation of growth with crown development, and other factors, and for an intensive study of the best way to apply the results secured on sample plots, as illustrated by the work of Krauch in District 3. But we are anxious, primarily, to learn what is going on in certain stands, in the matter of growth and losses from various causes. Nothing more detailed is needed. What, then, is the minimum that will give us what we want?

The size of plots is a factor that has even troubled research men. We believe, however, that the size will have to be governed very largely by the character and density of the timber, and may range from 10 acres of open, mature western yellow pine, to as small as a quarter of an acre in dense, uniform lodgepole. The more careful studies that are being made by Research go far to show that results on many plots must be applied to other areas through a study of the way different diameter classes respond to the cutting treatment that has been applied, rather than clapping the results on the whole area onto another site. Therefore, the plots should be large enough to give a good representation of all the essential diameter classes found upon the site concerned.

Research has also insisted that the plot should be accurately laid out and the area carefully determined. We cannot feel that this is at all necessary. What difference is it going to make whether we have five acres or 4.8 acres? We will simply fool ourselves into thinking that the stand we find is perhaps 6,000 feet an acre, whereas, if we had been more careful we would learn that it was only 5,880. What does that mean when the next five-acre area taken by chance may have only 4,000 feet upon it? The essential thing is to learn what the changes are from time to time and therefore the necessary thing is to get the same area each time, or even more specifically, the same trees. The moral of this is, tag all trees that are measured and blaze the outside boundary with the fact borne in mind all the time that the tagging is the more important thing of the two. This is the first of the fundamental requirements.

The second thing is to learn what the trees that have been chosen to represent the stand are doing in the way of growth as the years roll by. It is obvious that diameter measurements will have to be taken at intervals that should be approximately regular, although this is of secondary importance, as the results are reduced to a growth-per-year basis anyway. These diameters should be taken with a diameter tape as calipers are forever introducing upsetting factors. The other thing which requires study is height growth. This is a difficult problem, even on the plots laid out by professional plot makers. It has to be done accurately or it is not worth much. As an absolute minimum requirement, we propose the measurement of a number of trees, we can hardly say exactly how many, in each diameter class. The same trees are to be measured at each succeeding remeasurement, because diameter height relations have an unfortunate way of changing, following a cutting which releases trees and introduces other new factors. In view of the difficulties which have beset other people in handling this problem, we believe that we will have to go so far as to say that the points from which the tree height is measured must be tied down in some way to get around the difficulty caused by leaning trees. The easiest way of handling this would be to use a Forest Service hypsometer and stand each time close beside a tree whose number could be given on the record. This impresses us as sufficient.

A field sheet for recording the information on a plot of this kind need have but two columns; one for the number of the tree, and the other one for the diameter. It probably would not hurt to have a good wide third column for remarks, however, as on many areas there would perhaps be other things which not absolutely essential to the minimum requirement, might easily be added without much labor. Chief of these would be the notations as to pronounced unhealthiness or abnormality from any cause. Another sheet should be used for entering data which will form a basis for observing the changing diameter and height relations, one column giving tree number, a second column for height, and a third column for a description of the point from which the height is

measured. A fourth column for diameter would be handy but is unessential, as it is a repetition.

When it comes to office work, there is another point which must be taken into consideration even as a minimum requirement, and that is the necessity of always using the same volume table in compiling the results. Remarkable growth has sometimes been observed even in the most carefully laid out and measured plots, on account of overlooking this little item. These are the minimum requirements as I conceive them. At the same time I would like to register a protest on the fearful and wonderful sheets that have been devised for the office record of these plots, (the M summary forms). They are indeed stupendous. When Korstian was with us in District 4 we had one man who did not stand in awe of them. He is gone, however, and their very appearance scares everybody who might be interested in their content. Why not make a little card system cataloguing one tree to a card. Enter its number and diameter on the card and maybe its height, then shuffle the cards together to suit yourself, throwing them into inch classes, two-inch classes, height classes or any class. For the small plots that would be established administratively this system would be quite feasible and it is much easier to handle in the office than the great sheets that are considered essential for the intensive plots, at least in this District. Besides, as already pointed out, a small bunch of cards will not scare even a Ranger, while the impressiveness of the standard sheets will make even a District office man quail.

To conclude then, let me recapitulate. Choose your plot, tag the trees, measure diameter and height carefully, compile the volume by the same volume table each time and keep the office records simple. Thus will we get the essentials that are needed in forest management, while the experiment stations plough forward toward the whyness of the wherefore.

## Computation of Growth and Yield Studies

R. M. Brown

1. Assembling data

Amount of data available; kind and character.

Distribution of classes, representative of range of conditions, age classes, composition of stands.

Extremes at upper limits of yield studies need greater attention.

Classification

1. On basis of height growth.
2. On basis of age within sites.

2. Compilation of plot data; diameter limits

1. Diameter-height relationship
2. Volume table versus sample tree method
3. Crown classes to be included in normal yield tables
4. Units of measure
5. Construction of height-growth curves in site classification

3. Computations

1. Abnormal plots; methods by which determined and reasons for rejection
2. Averaging plots by height growth and age classes
3. Plotting and curving averages, replotting and harmonizing data
4. Interpolation to arbitrary classes for final tables
5. Checking against original data
6. Investigation of trends of growth curves on permanent sample plots necessary as an aid in compiling yield tables from temporary plots

4. Office Procedure in Computing

General rules and fundamental principles for
Rejection of figures
Multiplication and division
Logarithms
Additions - subtractions
Accuracy

## Notes on Computation of Total Cubic Contents of Trees

C. Edward Behre

The superiority of the cubic foot as a unit for measuring timber is well recognized and it is recommended that basic growth and yield tables be expressed in cubic feet for all management and scientific work. Dependable cubic foot volume tables are therefore necessary.

In the compilation and checking of cubic foot volume tables a question of accuracy arises which has not been seriously touched upon in the literature on the subject as far as I know. This is in regard to the method of computing the actual total cubic contents of the trees. In conventional instructions covering this point the stump is usually figured as a cylinder after allowing an arbitrary amount for the unusable portion, the intermediate sections of the stem as frustums of paraboloids by the Smalian formula and the tip as a cone. Results varying within a margin of 5 to 10% may be obtained in this procedure, depending upon the system used in sectioning the tree in the field and the method of handling the butt swell in the office.

If a given set of tree measurements are handled consistently a volume table worked up in the conventional manner by harmonized curves should give a satisfactory check against its basic data when tested as suggested by Bruce. The tentative standard set up by Bruce is that a volume table should measure its basic data within 1 per cent of the actual volumes. Now suppose another table were constructed in which the procedure in handling the measurement of the trees varied slightly, causing a variation in volume from 5 to 10 per cent. How could a test be applied to compare these two tables, or how could either table be satisfactorily tested for applicability to another set of material unless the volumes of the trees were arrived at in exactly the same fashion? How can a limit of error in testing cubic foot tables of 1 per cent be met when differences 5 to 10 times this amount may be caused by the method of handling the tree measurement in the field and office? If we are to place cubic volume table work on a sound basis the procedure in regard to this point should be standardized.

The following material selected at random from spruce data will serve to illustrate the point:

| Tree Number | 1 | | 2 | | 3 | | 4 | | 5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| D. B. H. | 5.2 | | 7 | | 9.8 | | 18. | | 17.2 | |
| Total height | 45 | | 42 | | 57 | | 76 | | 75 | |
| Volume #1 | 3.62 | +3.5 | 6.57 | +10.1 | 13.7 | +5.0 | 56.15 | +5.9 | 46.86 | +7.6 |
| " 2 | 3.47 | -1.0 | 6.22 | +4.7 | 13.31 | +2.0 | 55.72 | +5.0 | 46.76 | +7.3 |
| " 3 | 3.31 | -5.4 | 5.81 | -2.2 | 12.88 | -1.5 | 54.75 | +3.2 | 45.97 | +5.6 |
| " 4 | 3.50 | - | 5.95 | - | 13.07 | - | 53.04 | - | 43.59 | - |
| " 5 | 3.25 | -7.0 | 5.61 | -5.5 | 12.96 | -0.9 | 55.4 | +4.3 | 44.96 | +3.3 |

Opposite each volume is given the per cent variation from #4 taken as a base.

Trees 1, 2, and 3 were measured at intervals of 8.5' above stump as cut and allow a stump of 1 per cent of total height in calculation.

Trees 4 and 5 were measured at 10' intervals from the ground and allow no stump.

Volume #1, Stump as cylinder from point of cut.
Section by Smalian formula in uniform lengths throughout.

Volume #2. Stump as cylinder from point of cut.
Stump to breast height and breast height to first section computed separately.

Volume #3. Portion below breast height figured as cylinder, disregarding actual stump measurement. Other sections by Smalian formula.

Volume #4. Stump as cylinder from point of cut in trees 1, 2, 3 - no stump in trees 4 and 5.
Sections 1 and 2 combined and computed by Huber's formula. Other sections by Smalian formula.

Volume #5. Total volume from breast high form factors based on
$\frac{d}{D} = a + bl$ (Behre)

Comments

1. The conventional system always gives an exaggerated result and should never be used without modification.

2. Splitting the butt section in two by figuring separately to the breast high point (2) reduces this error some, but still figures the butt as two convex sections when in reality the taper curve is concave.

3. Neglecting all root swell below breast height frees the work of variable factor due to varying height of measuring stump diameter and gives a volume more nearly that actually used. Most convenient when sections are measured at 1/10 intervals. When root swell extends above breast high error in applying Smalian formula to first section offsets the neglect of taper below breast height.

4. Makes butt section independent of either the stump or breast height measurement by using the diameter of first section as the middle diameter of a double length section calculated by Heber's formula. Entirely eliminates volume in butt swell, but subject to wide fluctuations because entire volume of two lower sections are based upon the single measurement of the diameter of first section. Does not require a separate calculation. Sections of uniform length can be figured by formula $V = (2a + \frac{b}{2} + c + d + \ldots \frac{n}{2})l$

Advisability and Plan for Standardization of Growth and Yield Investigation Methods

Raphael Zon

Uniform methods for collecting field data for growth and yield tables are very essential.

This presupposes also uniform methods for the collection of data for construction of volume tables since volume tables are basic to growth and yield.

Such uniform methods are vital in providing the country and the profession with comparable figures of yield of different species and different regions and particularly necessary when the territory covered is large.

They should not be made obligatory, however, in investigations in the field of forest measurements. In such investigations there should be freedom for individual initiative to try out new methods, as only in this way progress can be assured.

No attempt should be made to force uniform standard methods for all conditions of forests.

Standardization lends itself most readily in pure even-aged stands and should be considered first of all for just such stands.

The fundamentals of growth have not yet been sufficiently determined for uneven-aged or mixed stands to agree upon uniform methods of procedure for such stands. There is still needed considerable preliminary mulling over the different factors entering into the problem. All that can be done for the present, as regards uneven-aged and mixed stands, is to give a critical review of the existing attempts.

Standardization, even in pure even-aged stands, should be of a twofold character; first, standardization as far as it can be agreed upon for one or several regions, and, second, for the whole country irrespective of the forest regions.

Below are given the factors upon which an agreement is needed for the preparation of volume, growth and yield tables for different regions and for the country as a whole.

Volume Tables

To be standardized regionally.

1. Top cutting limit.
2. Stump height.
3. Minimum D.B.H. - Ht.
4. Scale rule to use.
5. Log lengths.
6. Treatment of fractional inches.
7. Trimming lengths.
8. Use of total height - log height - merchantable height.
9. Tables for local use, based only on diameter.

To be standardized for all regions.

1. Methods of constructing total cubic content table. Points at which measurements should be taken and inclusion or exclusion of bark.

2. Number of trees needed as a basis for each D.B.H. class or for each D.B.H. - Ht. Class.

3. Method of construction, whether standard or form factor.

4. Standard methods for checking accuracy and applicability.
5. Consideration of site quality.
6. Consideration of age of timber.
7. Methods of measuring, whether tape or calipers.
8. Consideration of used and merchantable length.
9. Standard sheets.

Possibility of a universal table, advisability of taper tables on which to base future volume tables.

Growth and Yield Tables

Growth studies must be considered from the standpoint of individual trees and of stands. Yield studies must be considered from the standpoint of normal and empirical tables.

It should be a universal practice to either disregard or acknowledge economic age.

Growth Studies

Individual trees

To be standardized regionally.

1. Studies of volume increase.

To be standardized for all regions.

1. Methods of studying diameter growth by projecting the curve of growth or assuming the same rate.

2. Methods of studying height growth.

3. Consideration of density of stand, site, and crown class.

Stands

To be standardized regionally.
1. Size of plot.
2. Number of plots needed.
3. Basis height and diameter or diameter.
4. Distribution of plots.
5. Use of increment borer.
6. Current growth plots.

To be standardized for all regions.
1. Number of trees needed as a basis in each diameter class.

Growth Per Cent

To be standardized for all regions.
1. Selection of basic volume.
2. Use of volume or diameter.

Yield Tables

Normal Yield Tables

To be standardized regionally.
1. Size of plot.
2. Determination of volume.
3. Minimum merchantable size.
4. Density of stand.
5. Abnormal openings.
6. Shape of plot to eliminate personal equation.

To be standardized for all regions.
1. Method of site classification.
2. Method of eliminating abnormal plots.
3. Method of determining age.
4. Method of determining reduction factor.
5. Number of plots for an age class.

Empirical Tables

To be standardized regionally.
1. Size of plot.
2. Determining volume.
3. Minimum merchantable size.

To be standardized for all regions.
1. Site classification.
2. Treatment of opening.
3. Number of plots.

The Forest Experiment Stations may well become the centers through which such regional or country-wide standardization of volume, growth and yield tables may be brought about.

In the discussion here of the fundamentals to be considered in the collection of field data and working up in the form of volume, growth and yield tables, is laid the basis for a uniform procedure. The results of this discussion should be brought by the Forest Experiment Stations to the attention of the forest schools and other forest agencies within the respective regions.

Representatives of the different experiment stations should form a committee for preparing a plan for the collection, recording, and computing of field data for volume, growth and yield tables in so far as such uniform methods can be adopted for the regions and country as a whole.

This plan should form a part of the second volume of the Manual on Forest Research Methods.

All future work of a comprehensive character involving the preparation of volume, growth or yield tables should follow the standard plan.

If any modification in this plan, because of local conditions or the local character of the timber, should become necessary, it should receive the approval of the committee composed of representatives of the experiment stations.

Clapp - Mr. Zon's plan is to set up committees inside Forest Service to cooperate with outside agencies to standardize methods along this research line. Suggestions called for.

Dana - Should not other organizations be included on the committees from the start? Forest Service obviously will have to do the bulk of the work.

Zon - I have no objection to that.

Clapp - Temporary committee might help to crystalize action at once.

Munger - Suggests Washington office prepare tentative standardization and submit to field - both Service and outside foresters. I approve Mr. Zon's suggestions and plan very heartily.

Bates - If this standardization is going to be a text-book of methods I suggest some one write a text-book on Mensuration.

Clapp -- The suggestion is that we merely get together and agree on variations of methods which - as Mr. Forbes points out - are present in the text-books. No real reason for much of the present variation.

Bates - I do not believe there is any great or important variation especially in the western districts.

Clapp -- The desirability of attempting to standardize methods still further - this is the question.

Dunning - Favors it. Especially log rules and formulae for computing cubic contents. Hasn't Munns already started?

McCarthy - First thing is to standardize purpose of these investigations, standardize methods afterwards.

Munger - What should be standardized nationally and what should be left to local option?

Clapp - Get at desirability of the whole thing first.

Behre - There is this need. Keep away from the text-book idea, however.

Munns - A set of standards and units of measure cannot help becoming a text-book, but that is only a small part of the question.

Forbes - Standardization desirable because it will place the burden of proof on any man who chooses to deviate from it.

Frothingham - Approve Zon's suggestions in a general way.

McCarthy - Research is not primarily a business of production in quantity and until it enters that phase standardization is not desirable for best progress.

Clapp - Believe we have or will soon reach the stage of production in quantity.

Zon - In Europe the Experiment Stations got together to standardize methods so that results would be comparable.

Marsh - Strong for it on principle. Would be very valuable in my work.

Morse - We could use such standards to good advantage.

Chapline - Better standardized results or principles of experiments would help immensely in grazing studies. (Meaning that grazing could well standardize its procedure.) Object is merely to coordinate work between districts so results are comparable.

Clapp -- Standardization intended merely for quantitative production. The field being left wide open for initiative in newer studies.

Munns - Present condition and variations in volume tables is proof of necessity of standardized practice in this field. Tables have been prepared and stated in so many different ways that they are not at all comparable.

McCarthy - Believe continuous committee should handle this.

Show - Do not need to carry this too far, but there are many factors the measurement of which can be and should be standardized. Do not believe it is a committee job as yet - not a large committee at least - probably only 1 or 2 men best - to hang up something more definite to shoot at.

Bates - I do not think that the first section of the Research Manual has resulted in a single step of standardization.

Pearson - Mensuration work and its application is much more suited to standardization than other lines of research and obviously needs it.

Clapp - Any other details on the machinery to handle this?

Kittredge - Have the best machinery already available. Two probmens, regional and national. Experiment stations in position to speak on regional problem and should so speak. Then let Washington office harmonize national possibilities.

Clapp - Forest Service Committee the first step then?

Kittredge - Yes, then submit results to outside agencies.

Dana - Believe outsiders should be in on this from the start because ultimate aim includes them. Should get the nation-wide viewpoint first, then shoot at it from the regional viewpoint.

Kittredge - Agrees.

Behre - Cubic contents of trees the most important. Method of computation very important. See his paper on this subject - attached.

Clapp - Temporary committee appointed.*

(Munns then described the punch card tabulating or sorting machine.)

* Committee: Kittredge, Chr., Show, Dana, Weidman, and Munns.

## Report of Committee on Standardization of Forest Measurements

The object of the committee was to formulate the conclusions of the conference, to recommend machinery and suggest the steps to be taken in working out national and regional standardization.

1. The committee agreed that progress was possible in agreeing on national and regional standardization. It suggests the following plan:

2. Existing Forest Service organization to take initiative in starting rather than special committee.

3. That either J. Kittredge or E. N. Munns be delegated to prepare preliminary statement of points suggested for nation-wide standard with suggested standards for each.

4. That this preliminary suggestion be distributed through the Forester's office to stations, and districts and schools, State foresters, local sections S.A.F., etc., for criticism and suggestions.

5. That suggestions also be requested at the same time through experiment stations working through local sections of the Society for regional standards to supplement national standards.

6. That action which may be desirable beyond this point should be through the society at its annual meeting.

Committee: Show, Kittredge, Weidman, Pearson, and Behre.

## Additional Sections of the Manual Not Covered

E. N. Munns

Need for standardized procedure

Use of similar forms and methods in forest studies

1. Comparable methods
2. Uniform definitions
3. Correct forms

Preparation

1. Through compilation of material collected last season supplemented by methods obtained in circularizing other units.
2. One man job of compilation
3. Assignment to field men

### OUTLINE FOR MANUAL

Forest description

Physical factors of site
- Climate
- Topography
- Surface
- Drainage condition
- Soil
  - Humus
  - Litter

The Vegetative cover
- The tree cover
- Age, Height, Size, Quality
- Injuries and defects

Second story
Undergrowth
Shrubby cover
Living ground cover
History
- Origin of the stand
- Life influences
- Forest succession and retrogression
- Interference by man

Cutting
Fires
Grazing
Other influences of man

Forest types
Classification of types
Practical use of forest types
Methods of determination

Natural Reproduction
Methods of studying the effect of cutting and fires upon natural reproduction

Ecological factors affecting natural reproduction
Agents of migration
Succession
Competition
Pathological factors
Meteorological factors
Edaphic
Mechanical factors

Fires
Causes and kinds of fires
Character of forest burned
Effect of fire on forest
Effect of fire on forest floor

Cutting
Silvicultural systems
Brush disposal

Field methods - Sample plots
Short-time studies
Long-time studies
Permanent sample plots
Selection of areas
Classes of plots
Extensive plots
Intensive plots

Special reproduction studies
Measurement of physical factors
Future measurements and examinations
Forms

Fire studies
- Climatic regions
- Decisive factors for predicting the approach of fire danger conditions
- Collection of adequate meteorological data
- Correlation of fire and weather records
- Rate of spread
- Fire damage

Studies in Reforestation
- Similarity and difference in methods between natural and artificial reproduction
- Seed investigations
- Methods in seed production
  - Sample areas
  - Individual trees
- Other seed investigations
  - Seed extraction
  - Seed testing
  - Heredity
- Methods in nursery practice
- Methods in sowing and planting experiments

## Subjects to be Covered in a Manual on Forest Measurements

E. N. Munns

1. Research Methods in General
   - Permanent stations
   - Temporary stations

2. Forest Mensuration
   - Field measurements
     - Methods and instruments
     - Standards of accuracy
     - Units of measure
       - Height and diameter
   - Site classification
     - Basis
     - Determination
     - Application

3. Unit of Measurements
   - Height and diameter
   - Volume; board feet, cubic feet, cords, converting factors
   - Mill scales
   - Utilization standards

4. Volume Tables
    - Steps in preparation of tables
        - Number of trees
        - Points of measurement
        - Computing methods
        - Accuracy
        - Site volume tables
        - Local volume tables

5. Form Classification
    - Form in mensuration
    - Taper tables
    - Form factors
        - Form quotient
        - Frustrum form factors
    - Tor Johnson method

6. Studies of Individual Trees
    - Tree description - classification
        - Crowns; American, Swedish
        - Vigor and thrift
        - Size and age
    - Growth
        - Diameter, height, volume
        - Changes in form
        - Use of increment borer

7. Factors Affecting Growth of Stands
    - Site quality
    - Form of trees
    - Density and treatment
    - Composition

8. Studies of yield
    - Use of yield tables
    - Normal and empirical tables
    - Application to stands
    - Construction of tables
        - Collection of data
            - Empirical plots
            - Permanent plots
        - Compilation and computations
            - Site classification

Use of Statistical Methods in Forest Research

J. Kittredge, Jr.

Statistical methods are methods based on mathematical principles which facilitate the analysis and correct interpretation of masses of numerical data.

They are considered essential in physical and natural sciences, education and economics, why not in forestry?

Averages and their reliability. Average and standard deviation as measures of dispersion.

Normal frequency curve represents ideal distribution of such factors as heights, diameters, basal areas, volumes, numbers or measurements of leaves, seeds or crowns. Use in predicting normal distribution from a small sample.

Probable error as a measure of the range of inaccuracy to which any constant computed from a variable series of data is subject.

Curve fitting by method of least squares versus free-hand approximation curves.

Coefficient of correlation as a measure of the degree of relationship between two series of observations. Significance of different degrees of correlation. Example of use in evaluating relationship between wilting coefficient, capillary moisture, humus content, water soluble matter, and clay content.

Partial correlation as a measure of relationship between two series of observations when influence of other causal factors is kept constant. Use of correlations in expressing relationships between survival or growth, fire hazard or liability, and causal factors of environment.

Reliability of sample measurements indicated by 2.7 times the standard deviation of the mean, which gives chances of 142 to 1 that the true mean derived from an infinitely large number of cases would fall within the range thus established. Example of jack pine yield plots indicates need of 30 plots to give not to exceed ten per cent inaccuracy for forty-year age class.

Application of statistical methods involves increased computing and requires trained judgment to determine justification of use of methods and interpretation of results.

# PART III. FOREST RESEARCH - MISCELLANEOUS TOPICS

## The Influence of Growth Conditions Upon Wood Properties

B. H. Paul

It is the purpose of the Forest Products Laboratory in conducting a study of the influence of growth conditions upon the properties of wood, to straighten out the conflicting ideas prevailing with respect to the reasons for variations which occur in the wood of any species, to find out whether there is any foundation for prejudices which exist against material from certain localities, and to discover, if possible, practical relations between growth conditions and wood properties which are of value in the practice of forestry.

The results of foreign investigations do not furnish much practical or conclusive evidence of the relations between growth conditions and wood properties. Many of their deductions and conclusions do not appear to be based upon sufficient experimental data. However, they present a most valuable illustration of the scope and the complex nature of the problem. Hartig's "Nourishment Theory" offers an explanation of some variations in specific gravity of wood which could not be accounted for in any other way. He states that the quality of the wood produced is dependent upon the relation existing between fertility of the soil, transpiration of water by the crown and assimilation.

In the studies of the influence of growth conditions made by the Laboratory, the specific gravity of wood has been used as an index of its quality, since the values for most wood properties increase with the specific gravity. Although not all properties increase in the same ratio, specific gravity offers a better criterion of their quality than any other single determination.

The results of studies of white ash which have been under way for the past two years are summarized as follows:

A comparison of specific gravity values of white ash from the Appalachian Mountains, the Mississippi Valley, the Ozark Mountains, and Ohio indicates that the influence of locality upon the properties of the wood formed is not as great as the influence of the other factors which directly affect the growth of the individual trees.

Under normal conditions of growth the wood having the highest specific gravity is found at the base of a tree, but white ash trees which had grown under excessive water conditions in the Mississippi bottomland contained wood of lower specific gravity near the ground than at a height of 16 feet or more in the bole.

The width of annual rings or growth layers is not an index of wood quality of white ash unless considered with respect to the life history of the tree. This conclusion is fully warranted by the following deductions from the specific gravity determinations:

1. The rate of growth of white ash during the early life of a tree does not seem to influence the specific gravity, since wood of high specific gravity was formed whether growth was rapid or slow.

2. Trees which maintained a nearly uniform rate of diametral growth did not show any wide differences in the specific gravity of the wood produced at different periods in their lives.

3. A retardation of normal growth, as exhibited by a sudden change in the width of growth rings, resulted in the formation of wood of lower specific gravity.

4. Restoration of normal growth resulted in the formation of wood of higher specific gravity.

In two woodlots which have had little or no thinning the white ash trees show a decrease in rate of diametral growth due to crowding. This decrease is accompanied by a considerable falling off in the specific gravity of the wood.

White ash trees from another woodlot thinned as the result of logging 30 years ago show a remarkable increase in rate of diametral growth since thinning and during the same time have produced wood having no abnormal or abrupt changes in specific gravity values. White ash wood from the thinned stand shows only about half as much variation in specific gravity as that from the unthinned stands.

The results of this investigation show that when other conditions are favorable, thinnings in a crowded stand of white ash will not only assist in a continuation of the normal growth rate but will tend to prevent a falling off in the specific gravity of the wood formed.

There may be other factors of growth having equal or even greater significance than growing space. These factors must be determined one by one through a careful study of individual trees which have been growing under as nearly uniform conditions as can be found. After the relation of any single factor has been determined for a number of individual trees, its importance in forest stands and the value of its general application to forest management can be determined through the establishment of sample plots under conditions which will allow the influence of that particular factor to predominate.

A most valuable correlation with this study would be a determination of the relation between growth conditions and the percentage of high grade clear lumber that can be produced in a stand. The premium placed upon clear lumber makes the question of growing high grade lumber far more important from the standpoint of financial returns than the production simply for maximum volume.

The value of a study of the influence of growth conditions may be multiplied many times by a proper correlation with the different lines of research both in silviculture and forest products.

The next crop of timber will differ greatly from the product of the virgin stands. There is urgent need of presenting the timber-growing public with authentic information, not only in regard to volume yields under forest management, although that would be a long step in the right direction, but to this should be added a knowledge of the quality and relative future value of the product which it is possible to produce. Silvicultural practice should aim toward a production of high grade material in short rotations.

Forbes - suggested the wider selection of specimens might have given greater assurance to results.

Newlin - answered this by pointing out the correlation of the ash study with strength tests on other species. He stated that specific gravity is not directly related to width of ring.

Koehler - Advanced the theory that the balance between crown space and environmental factors may cause the differences in sp. g. and therefore strength.

Newlin - in reply to a question said the width of summer wood is not a general criterion of strength in wood.

Tiemann - commenting on the low strength of wood in the base of swamp grown trees, pointed out the reaction of certain southern swamp oaks which behave badly in drying. These trees are filled with water in small cells and collapse in drying. This is not true in northern and upland oaks.

Weidman - suggested the use of western yellow pine for continuation of the study. Since acceleration after cutting is commonly found.

Newlin - gave his opinion that this study should continue on hardwoods since the reaction of softwoods was known to be different.

Hunt - pointed out that strength and durability were not factors of primary importance in the use of softwoods, since most of them were used in construction where these factors were not considered. On the contrary, these two factors are often very important in the use of certain hardwoods.

Bateman - announced the results of study of toxic properties in the heartwood of certain durable hardwoods. Durable hardwoods thus far studied show toxic properties. Softwoods have volatile oils which serve this same purpose.

Kittredge - suggested the close relation of the study to size of crown for various crown classes in further study.

Rue - Discussed briefly the needs of the pulp and paper industry in relation to this study of the influence of growth conditions. Strength and durability of no importance except as weight increased fiber production.

and

Correlation of Utilization in Silviculture

S. T. Dana

Forest utilization is so closely connected with the practice of silviculture as to be almost inseparable from it. Theoretically, desirable methods of cutting can be devised in the light of the silvical characteristics of the species and types concerned; but these are of little practical value unless they can be profitably applied in the woods. It is uselsss, for example, to advocate the clear cutting of northern hardwoods as the ideal silvicultural method if there is no market for the smaller material.

The successful silviculturist must, therefore, have a good working knowledge of forest utilization. He must know the uses to which given species can profitably be put as well as their silvical characteristics; he must know the effect of forest management on the quality of the material produced; and he must know the limitations placed on silvicultural practice by utilization difficulties.

On the other hand, the utilization expert cannot work to best advantage unless he knows what effect the method of logging and the size and character of trees taken will have upon the forest from a silvicultural standpoint. Clear cutting in western yellow pine may result in a total lack of reproduction, while diameter limit cutting on an exposed spruce slope may result in heavy windfall among the trees left. Under certain conditions either of these methods might be desirable from the standpoint of utilization alone; but from the standpoint of forest management their use would be a costly mistake.

The relation between properties of wood and growing conditions, which will be brought out in another paper, is of interest to both the silviculturist and the forest products specialist, and constitutes another tie between them.

The northern hardwoods type in Maine may be used as a specific illustration of the need for close correlation between utilization and silviculture. At present, because of utilization difficulties of one kind and another, cutting in this type is on a very small scale in comparison with the area involved, and there is virtually no choice as to the method of cutting to be used. In order to permit exploitation on a more extensive scale and in such a way as to secure the best results silviculturally, information is needed which will make possible the profitable utilization of the species involved through

a. Development of new uses.
b. Increased efficiency in logging and milling operations.
c. Overcoming of present transportation difficulties.
d. Development of new or improved markets.

There is hardly a type in which information along these and similar lines would not increase the effectiveness of forest management by allowing freer opportunity for the application of those methods of cutting which are best from a silvicultural standpoint. Other ways in which forest products investigations can be of help to the silviculturist are in developing methods for the profitable utilization of small and inferior material of all sorts; and in pointing out desirable substitutes for trees that are intrinsically valuable but cannot well be favored in forest management, such as chestnut.

The present division of responsibility for investigations in utilization and in silviculture between the various forest products offices (including the Madison Laboratory) and the experiment stations should probably be continued. It is, however, highly desirable that there should be a closer coordination between these two lines of investigation than has previously existed. This should involve not only long range correspondence, but occasional personal conferences between members of the two forces. The practical application of silviculture is limited by utilization possibilities; while the character of the material produced and the perpetuity of the forest (which is the ultimate aim of the utilization specialist as well as the silviculturist) are in turn dependent on the silvicultural method used. It is essential that the two get together.

Frothingham - mentioned the chestnut blight study in the Appalachian region as a case in which the study of replacement in blight injured stands will be correlated with utilization of chestnut for tannic acid production.

Winslow - emphasized the need for closer cooperation between the Laboratory and experiment stations to correlate these two phases of the forest problems.

Zon: To what extent is the Forest Service justified in undertaking economic work?

Clapp: Largely up to the Branch to secure proper correlation. Application made from timber growing not economic studies.

Zon: Gather data to supplement the work in the Capper report - forest taxation, land areas, swamp lands, etc. Agricultural development to forestry.

Greeley: Very desirable for station to check up information on forest conditions with view toward accumulating correct data and information. Taxation hardly a phase for the stations. Function of a station is to record all information and to keep in touch with other workers in the field. Cases of agricultural development are really a part of forestry.

Dana: Collection of data is necessary for planting, fire protection, etc. Clearing house for forest statistics and resources.

Greeley: Hardly function of the forest experiment station unless some very exceptional region. Perhaps later the Forest Service may undertake the compilation of data such as that in the Capper report. Forest experiment*stations should keep clear of this class of projects.

Dana: How much wood is used and grown in a State? An economic survey of the State.

Greeley: Keep in touch with work, but scarcely necessary.

Chapline: An analysis of a State survey would be of assistance to others. Is the analysis of such data a function of the forest experiment station?

Greeley: No objection to analysis, but not in collection. Cooperative studies have been made in past. Station should not be loaded up with such projects. No economic material survey, however, should be made.

Clapp: Growing demand in District for research work from administrative organization. What should be the policy as to administrative men?

Greeley: Subscribes in so far as the work will not interfere with administrative duties. Same position as to funds in administration as in research. District Forester should provide for such research work as his plans could justify.

Clapp: Should such work be handled as in Research?
Greeley: Yes.

Functions of Forest Experiment Stations;
Research; Ways and Means of Putting Results Across
In the Forest Service, with Private Owners

Raphael Zon

1. Difference Between the Western and Eastern Experiment Stations

In the West the administration of National Forests forms the predominant field for the work of the experiment stations. In the East privately or corporately owned timberlands are the chief field of investigation and application. In the West old, mostly virgin timber is the main field of investigation. In the East the cut-over and second growth are the prevalent stands.

2. Advisory Committees

Since the work of the eastern experiment stations is confined to privately-owned lands, the interest of private timber owners must be secured. Advisory committees to the experiment stations, composed of representatives of the different organizations in the region interested in forestry, are one of the means.

3. Research Work

Although scientific studies of a thorough character are the function of all the experiment stations, the eastern stations are more under pressure for immediate results, even if they are only technical information and not of fundamental character.

4. Independence of Action

The activities of the eastern experiment stations being closely interwoven with the activities of the private timber owners and the willingness on the part of the latter to assist in the work of the station, make it necessary in the conduct of the work to safeguard the independence of its conclusions and results secured. It is altogether too easy to commercialize the work of the eastern experiment stations because of the assistance constantly received from the private timber owners.

5. Ways and Means of Putting over Results

Demonstration areas are the most effective way to show the value of scientific results secured by the stations. Petersham Forest in the East and Cloquet Forest in Minnesota, where certain forest practice is demonstrated, will mean more to private timber owners than volumes of printed material.

6. Cooperation with Private Owners.

Application of certain methods of brush disposal, thinnings, or even methods of cutting are often possible upon private timberlands where the station merely works out a plan and the private owner carries it out.

7. Cooperation with Lumber and Pulp and Paper Organizations in undertaking certain forest practice under the auspices and with the financial assistance of the trade organization on the land of some of its members.

8. Cooperation with Scientific Institutions, such as academies of sciences, in undertaking or stimulating certain phases of forest investigations.

9. Cooperation with Universities and Forest Schools within the region, either by giving occasional lectures or suggesting certain lines of forest investigations by the teaching staffs, or by establishing forest seminars for the discussion of forest topics.

10. Encouragement of the Establishment of Research Fellowships, either by universities or through endowments by private individuals.

11. Cooperation with Agricultural Experiment Stations, State Forest and Conservation Departments in undertaking cooperatively certain forest investigations or stimulating such investigations by agricultural experiment stations or State foresters.

12. Personal Contact of the Station Staff with Private Owners or Scientific Workers in Allied Fields.

13. Cooperation with the Agricultural Extension Service, particularly with forestry extension specialists wherever they exist.

14. Distribution of Technical Information put out, as the result of scientific investigations, among a large number of private timber owners and scientific leaders, similar to the technical notes sent out regularly by the Forest Products Laboratory.

15. Publicity

Frequent distribution of information upon the results of the station's investigations in newspapers, trade and scientific journals, and also farm weeklies.

16. Making the Experiment Station an Institution in the Region to which all those interested in forestry will look for technical information on the practice of forestry.

17. Talks before Trade Organizations, Scientific Organizations, Women's Clubs, Rotary and Kiwanis Clubs, and similar organizations on the value of forest research and its application to the solution of forest and land problems.

18. Participation in State Forestry Associations

19. Becoming the Moving Spirit in the Local Sections of the Society of American Foresters.

## Functions of Forest Experiment Stations

S. T. Dana

Federal Forest Experiment Stations should exercise an active leadership in forest research in the regions in which they are located. Their function is threefold: (1) to conduct research; (2) to make the results available in usable form, and, so far as possible, to see that they are put into practice; and (3) to stimulate and coordinate research on the part of other agencies that are or ought to be doing work in this field. A station's effectiveness should be measured in part by its success in the latter respect.

The research work of the station itself should include both the bringing together and making available of existing material, and the securing of original data. To some extent the two lines of work overlap, and both will ordinarily be included in the same project. Particular care should be taken to give due credit to other agencies in the use of any material collected by them.

Problems of immediate urgency and outstanding importance should be given preference in the selection of specific projects. So-called fundamental research should not be neglected, but should be developed just as far as necessary to obtain really satisfactory answers to the problems under investigation. Thus, if a study of reproduction on cut-over areas shows the need for intensive work in meteorology, or soil physics, or soil biology, there should be no hesitation about undertaking it. The assistance of specialists in allied fields will frequently be necessary to do this. There should be an increasing tendency to emphasize fundamental research as additional work of an empirical character on more practical problems is undertaken by other agencies.

The field of the experiment stations should include forest protection, forest production, and forest management. Work in forest entomology and forest pathology will have to be done by representatives of the Bureau of Entomology and Plant Industry detailed to the various stations. Their work should be done in accordance with working plans approved by both bureaus and they should be under the administrative direction of the experiment station director, who should be responsible for seeing that the provisions of the working plan are carried out.

The stations should keep in close touch with all investigations in forest products and forest economics of interest to their region. Moreover, the stations should not be precluded from themselves doing work in these fields when other agencies are not able to handle problems of urgent importance. This is particularly true in the case of forest economics, since the stations can hardly function effectively without a rather intimate knowledge of such points as forest resources, present and future wood requirements, wood exports and imports, price trends, land policies, relation of taxation and fire insurance to forest management, etc.

Results can be put across, both in the Forest Service and elsewhere, by scientific publications, popular articles, talks, demonstrations, and personal contacts. Newspaper publicity is of value chiefly in securing recognition and support of the station, and may easily be overdone. It should be an integral part of the station's work to see that the applicability of its results is demonstrated in actual practice. The establishment of demonstration areas in strategic locations on Government, State, or private land is therefore most important. Activity along this line should not, however, be expanded to point of doing what is commonly known as extension or service work.

Within the Forest Service, experiment station findings should be circulated promptly and administrative officers held responsible for seeing that forest practice is in accord with them. So far as possible the station should be represented on marking boards and at important management conferences. Outside of the Service, in the West as well as in the East, a special effort should be made to establish personal contacts with influential individuals and organizations. A strong advisory committee should be helpful in getting results put across as well as in formulating the program of work. The plan of having "liaison officers" who devote their entire time to bringing about the practical application of research results may prove advantageous both in the Service and out. At least a fifth of the station's time may well be devoted to work of this sort.

In addition to their research activities, experiment stations should keep in touch with other phases of forestry in their regions, as, for example, the development and practical working out of State forest policies and the practice of forestry by private owners. This is particularly important in regions where there are few National Forests and where the District organization is necessarily less active than in the West. Under these circumstances the stations may well, within reasonable limits, act as the Service representative in cases where local representation is advisable.

Functions of Forest Experiment Stations; Research Extension Work

S. B. Show

A. Research Work

1. Securing and analyzing of technical information. Requires well trained men.

2. Explaining and proving correctness of empirical results by so-called fundamental research. Requires experienced and thoroughly trained technicians.

B. Extension Work

3. Placing technical data of proven reliability in shape for application as methods and practices instead of principles. Requires intimate knowledge and experience of administrative problems.

4. Securing application of results of research to specific administrative problems by key men or organizations. Same requirements as #3 plus ability to talk the language of administrative men.

C. Economics of Forestry

5. Studying and demonstrating the bearing of results of research on broader aspects of forest economics and forest policy, e. g., yield studies as basis for land policy; fire research as affecting safety of investments, and hence a determining factor in land policy; relation of forests to future population, as a factor in forest management. Requires not only technical ability in forest research but wide experience and training as economist.

D. Correlating Work

6. Coordinating all phases of forest research work by various agencies.

E. Extension Work

I. Objectives

a. In so far as specific researches are concerned, to bring to potential users of results, material in such shape that it can readily and directly be applied in practice, i. e., to have definite target and definite projectile.

b. To hold shot gun publicity aimed at non-users of results to rational minimum.

c. When something worth while has been done under #5 above, reach widest possible audience, particularly associations of farmers and wood-users, etc.

d. To secure incorporation of results of research in teaching texts of professional schools.

2. Methods

a. Actual demonstration most effective method of extension. Should pick key man or organization and attack a specific problem.

b. In written form, professional presentation should come first supplemented by rewrites for special or non-professional audiences.

3. Problems of Extension Work

a. Danger of attempting to combine research and extension ability in one individual.

b. Need of clear-cut limit of place of extension work in research activities, particularly general publicity.

c. Securing public interest and support without serious sacrifice of research activities.

Clapp - How far should the idea of a committee on research be carried? Committees have been appointed by the Secretary of Agriculture to correlate research work within the region covered by station. Plans have not gone far enough to demonstrate its benefits.

Zon - The Lake States Committee is composed of thirteen members; deans of forest schools and agricultural schools, lumbermen's associations, pulp and paper industry, wood-using industries, and State forest departments. They are a representative group of men. Letters of acceptance show great interest in the plan.

Frothingham - The Appalachian station will be ready in a short time to adopt this plan. We are already doing this on a small scale without the formality of appointments. The prestige of appointment would materially help the station.

Forbes - The plan is well worth while but it is doubtful if many men could be gotten together in the South. Probably two meeting places would be necessary. It appears feasible as a formal plan. Is there any objection to the station doing extension work, such as sample plots and demonstration areas on a large scale?

Clapp - This depends primarily on the purpose. It is doubtful if extension work on a large scale is justified in the South. Some extension work is advisable, especially where it will accomplish something definite. Depends on projects, location, interest and importance.

## Correlation of Grazing and Forest Research

W. R. Chapline

### Importance of Grazing to the Forester

We all recognize forestry as the best economic use of forest land with timber growing the primary use.

Grazing, if properly adjusted and properly coordinated with all other uses, may be made to utilize its share of the forage crop occurring on natural openings in the timber and as an understory in open stands without economic loss in the production of timber or injury to other uses. This use, in turn, furnishes an annual revenue to the timber owner for taxes, protection, and other current expenses, and is of especial value on slow-growing and low-producing timberland.

The value of livestock production is important. The National Forests alone produce at present prices possibly $35,000,000 of meat and wool per year. This industry must be maintained and stabilized.

The better understanding of the forestry problem by the 40,000 grazing permittees on our National Forests and the agencies with which Grazing is cooperating is also of no small importance. Witness several Districts' cooperation in fire protection.

Furthermore, grazing reduces the fire hazard in so far as it utilizes the palatable vegetation and breaks up the litter as well as by forming fire lines by its trails and driveways.

To handle the grazing situation satisfactorily and receive the benefits without injury, the forester must know proper stocking and the other basic principles of sound management of range and livestock. It is one thing to make the abstract statement that grazing injures timber reproduction, watersheds, wild life, and other uses of forest land, and it is quite another to state under what conditions grazing does and does not cause damage.

Possibly one-half to two-thirds of the potential timberland in the United States should not be grazed because of lack of available forage. Approximately one-fourth of the timberland in the National Forests is of such a character.

Nor can the forester allow twice the number of stock the forage will support to remain on forest land and expect to have proper reforestation, satisfactory watershed protection, economical meat production, a stabilized livestock industry, or other satisfactory use. He may not have actually increased the stock but if he has allowed the same number to remain on cut-over areas where the cutting operations and slash have reduced the carrying capacity 50 to 75 per cent or where an initial slight overstocking is continued until the deterioration has reached such figures, the same result is obtained. The situation as it relates to timber production should be met as far as it can by systematic planning ahead in relation to timber cuttings rather than by waiting until serious damage from livestock is actually taking place and then attempting to remedy it by sudden adjustments in use of range.

## What the Branch of Grazing Has Done to Coordinate Grazing with Other Uses of the Forest

The Branch of Grazing has, through its investigations, administrative practice, cooperation with others, and analysis of the work of others, determined the fundamental principles under which grazing should utilize forest lands. While this work is admittedly not complete, it has reached a point of sufficient soundness to be used as a general basis for correcting unsatisfactory practice. This includes:

1. The essential fundamental principles of sound, stable, economical grazing use of forage on western ranges, including standards for proper stocking and proper seasonal use of different types, proper handling of livestock on the range, and other important phases.

2. The main adjustments in grazing use which will prevent economic injury to timber reproduction.

3. The principal adjustments in grazing use are necessary to prevent excessive run-off and erosion.

4. The extent to which grazing may be used without detriment to other uses in reducing the fire hazard as well as some of the effects of fire on herbaceous and browse vegetation.

5. The principal relations of climate to herbaceous and shrubby plant growth.

6. Some of the relations of grazing to wild life.

I would not wish to give the impression that the problem of range and livestock management is solved. We have hardly scratched the surface but as far as we have gone we have aimed to lay a solid foundation on which to build our future investigations. Nor has the development of principles been the only aim. The direction by the Office of Grazing Studies of such important administrative phases as the grazing reconnaissance work, the application of the management plans developed thereby, the work of the technical grazing men, and to a certain extent the general application of improved grazing principles, has given a close coordination of the investigations and administrative practice which has been mutually beneficial to the development of the principles and their application.

In preparing permanent grazing management plans by reconnaissance we consider current plans for handling all uses of the forest before entering the field. Consideration of all phases is then given right on the ground and the final analysis and grazing management plan is the combined thought and judgment of the reconnaissance organization, the Supervisor, and the District Forester.

The technical grazing men have been recruited largely from trained foresters, and approximately 80 per cent of the present organization have had such training.

Other Work of Range Investigations

The Forest Service has been charged by Congress with the study of range management on the public domain as well as the National Forests. The arid and semi-arid grazing land unsuited for timber production has been estimated at 665 million acres and the woodland pasture at approximately 280 million acres additional. This is the area to which the grazing investigations of the Forest Service should eventually apply. In 1920 there were over 14 million cattle and horses and 19 million sheep and goats in the eleven western States. These numbers would be materially increased by including the livestock on the semi-arid pasture lands of the Great Plains and those on woodland pasture. With our meager appropriation the whole problem has hardly been touched, though we are now working on various phases of it ourselves and on others in cooperation with State agricultural colleges and other bureaus of the Departments of Agriculture and Interior. Two of our experiment stations are experimental cattle range areas off the forests in southern Arizona and New Mexico, and we are cooperating with the Bureau of Animal Industry at their sheep experiment station in Idaho.

To adequately handle the western range problem will require the establishment of five or six fully manned and fully equipped regional range experiment stations and close coordination of effort and cooperation with all concerned. It is not a question of more stock nor hardly financing or better stock but rather more economical production through better care and management of both range and stock, many phases of which are yet to be determined.

## Specific Correlation of Grazing and Forest Research

With this background it will be seen that there is need for correlation of effort between grazing and forest research. These come especially in the study of timber reproduction, erosion, watershed protection, fires, brush fields, climate, and indicator values of herbaceous plants.

The relation of grazing to timber production is probably the most important one and holds the greatest interest for the forester. We should not only determine whether grazing does damage, but we must determine under what grazing conditions damage will be economically serious, and what is really damage from the final timber production standpoint. We need more definite information as to a satisfactory stand of reproduction at different ages and under different conditions. Some benefits may also be developed.

Our study of grazing in its relation to watershed protection, run-off, and erosion has been correlated in general with the work along this line done by Pearson, Munns and others in the Branch of Research. Much additional study is needed. The determination of the part which herbaceous vegetation, shrubs, and trees play in their control of run-off and erosion is an important feature.

In the study of the relation of grazing to fire we need to more definitely determine the extent to which grazing may be used in reducing fire danger and the influence of the factors affecting. It is equally important to determine the true effect of fire on forage in different vegetative types and growth conditions. The work in fire research improves the background for developing the grazing phase.

Rather fundamental studies of the relation of climate to plant growth, especially herbaceous and shrubby growth, have been made at the Great Basin Experiment Station. The discussions have shown clearly the need for a thorough knowledge of climate in making plans for control of fire.

The relation of grazing to brush fields has had little investigation. The areas that are truly brush rather than browse are used very little at present. They are a big value in watershed protection, and yet they are, as has been shown by Mr. Munns, to be as well a serious fire hazard. If the true possibilities of use of this type of land for grazing without injury to the watershed can be determined, there would be an assistance in fire protection and a more economic use of land.

Studies of use of existing herbaceous vegetation as indicators of planting sites and possibly also of other measures of timber management may prove to be of considerable value.

There is at present a certain correlation of grazing and forest research through the consideration of both phases by the investigative committee in each district. A better understanding and appreciation of the results of grazing investigations by research foresters and more thorough keeping up-to-date in the progress of forest research by grazing investigators will go a long ways toward better coordination of effort. Visits to forest experimental areas by grazing investigators and to grazing experiments by forest research men should be of great value in the development of methods, in a better understanding and appreciation of all factors, in the analysis of results, and in other features of the work.

COMMENTS ON CHAPLINE'S CORRELATION OF RESEARCH

Hoffman - Grazing of importance. Measure of influence of grazing on reproduction. Also there is a chance of grazing tiding over forestry on scantily stocked reproducing areas.

Greeley - Are men in Grazing and in Research in the Southwest in accord in damage to natural reproduction?

Chapline - Men are not entirely in accord and due to difference in viewpoint.

Greeley - Is Grazing to surrender and permit Research to go ahead as to methods?

Chapline - Grazing found out about natural reproduction before Research did.

Pearson - Research has a different problem. Grazing should have carried out administration recommendations. Had to approach from Research standpoint in order to assist and assure proper forest management. Recognizes the importance of grazing in research work. Conditions are often extreme in southwest. Natural reproduction is important and grazing does considerable damage, but grazing must be stopped in many areas. Grazing is important on areas where restocking is at a low margin. Grazing must not interfere with the establishment and growth of trees. Reduces itself entirely to the basis of what is on the ground. Lack of reproduction is the real problem.

Chapline - Not a question of damage to reproduction, but a question of the real carrying capacity of the range. Improper utilization of range is at the root of all the trouble. Palatability of forage is a large factor, as is also the amount of the apparent feed.

Marsh - Situation in southwest is a most serious reflection upon administration. Grazing's recommendations were not carried out. Hill's investigations again revised and checked and now part of policy of sheep exclusion on sale areas. Double grazing by both sheep and cattle an important factor, especially where cattle are also involved. Demonstration now as to whether sheep should be allowed with them, whether they should be excluded. Grazing studies should be carried on through research work.

Pearson - Grazing accepts grazing damage as an axiom. If Research should accept that, then there would be no reproduction on cut-over areas of western yellow pine. Without natural reproduction at the time of cutting, the seedlings are damaged and grow under a handicap. N. F. force sees no damage but only the utilization of the range.

Show - Grazing is a secondary use in the management of the N.F. Research and Grazing have a common meeting ground on cut-over areas, where grazing affects slash and also natural reproduction.

Tiemann - Cited Australian experience in eucalypts.

Pearson - Erosion problem serious in region below the yellow pine type. How should lands be handled from grazing standpoint? There is a clear relation between grazing, erosion and fire. Heavy grazing has erosion and no fire; without grazing there are fires. Erosion in brush type is important.

Kotok - In California the question of fire hazard is important. Some argue that the cover crop should be removed to reduce the fire hazard and others vice versa. Is there a proper balance between cover type and reduction of hazard?

Munns - Close relation between grazing research and silviculture in relation to fire and erosion in D-5. Necessary adjunct of any intensive study of watershed relationships. Without a correlation of work there will be no real progress.

Greeley - D-3 is much concerned in erosion problem. This has come up in the West. Are we giging enough attention to this problem of erosion?

Munns - This is a question of land use, productivity. Need additional men in grazing research work, and attached to experiment stations. Grazing should assign men to each of the stations as rapidly as they can. Grazing an important adjunct of forestry in proper land use.

Clapp - Have not the men at present time.

Kelley - Big black scars in D-3 due to erosion and grazing. Erosion is one of the most important problems in Southwest. Silt is a big problem in our watershed areas. The Roosevelt dam problem is severe.

Marsh - Permanent sample plots at Fort Valley have given many answers. Big field for research work in fire studies; and erosion situation is one part of the problem. Investigation Committee has recommended new projects but need more personnel. Can use considerable additional men to good advantage. We should not drop the S projects. Projects recommended include engineering work on gully obstruction, damage survey of Salt River drainage, proper use of livestock, value of different species and exotics to control erosion.

Chapline - No projects going on now. Studies have been made in Great Basin. Ten years ago Grazing noticed erosion damage. Southwest has a severe erosion problem and must reduce cattle to a low figure if erosion is to be prevented. Foresters and grazing men have in past tried to prevent reduction. Intensive use of range is hard to determine. Cutting changes the composition of the forage up in the forest.

# PART IV. REPORTS ON SILVICULTURAL REQUIREMENTS FOR THE PRINCIPAL FOREST REGIONS OF THE UNITED STATES

## PART IV. DIGEST OF REPORTS ON PUBLIC REQUIREMENTS, DESIRABLE PRACTICE, AND DEVASTATED LANDS FOR THE PRINCIPAL FOREST REGIONS OF THE UNITED STATES

The following abstracts represent the digest or synopsis of the reports on public requirements for keeping land continuously productive; desirable forestry practice; and devastated lands. These reports were prepared for the principal timber regions of the United States with the purpose of showing what measures are necessary to keep forest lands from being devastated. They outline from both the standpoints of minimum requirements and more desirable practice the silvicultural and production measures which are necessary to prevent forest devastation. They also take cognizance of the land which has already been devastated, and measures which are necessary to restore this to production.

The digest of material presented at this meeting is not conclusive, but was assembled to make possible the comparison of conditions in the several regions, and enable the authors to correlate their results as far as possible for the entire United States.

It is expected that these reports will be published in the next two years.

### Digest of Public Requirements Report for the Douglas Fir Region

Thornton T. Munger

The purpose of this study is to determine the methods of woods management which are essential to keeping ultimate forest land productive of timber crops in the Douglas fir region.

Most of the privately-owned timberland of this region is of the Douglas fir type proper (50 per cent or more of this species) though the fog belt type and the high mountain types are distinguished also. The management of the former is about the same as for the Douglas fir type; the latter are not important at present.

Douglas fir has every characteristic favorable for its abundant reproduction after logging. Much of the natural reproduction so common on old burns and logged-off lands comes from seed stored in the duff. The seed cast by the old forest germinates on the first summer days after logging. Slash burning should, therefore, be prior to the germination of this seed, for if delayed the sprouting seedlings will be killed and chances of natural reforestation lessened.

Slash burning has little, if any, benefit as a reproductive measure, but it is generally agreed that it is necessary in order to lessen the fire menace. Slash burning does not eliminate the fire menace, however.

Fall burning of slashings has administrative advantages over spring burning, but the latter is more favorable to reforestation. A semi-annual clean-up is much to be desired; both seasons have their advantages, but none of their disadvantages outweighs the desirability of burning at both seasons.

Single seed trees left in logging are some help in reforestation, though their effect is not for a large radius.

It is the present logging practice to cut absolutely clean, leaving only trees of no merchantable value, to remove the logs with steam engines either by the overhead, high lead, or ground yarding method, and to burn or to allow the cut-over area to burn over, from one to three or four years after logging and sometimes repeatedly. The area is left bristling with snags and sometimes with small trees, which are killed by the slash burn. Most operators take many precautions to prevent accidental fires, but they are intended for the protection of the virgin timber and the logging investment, rather than the logged-off lands.

In spite of practically no conscious effort to encourage reforestation and protect the cut-over acreage, it is estimated that from 40 to 80 per cent of such lands are now reforesting more or less satisfactorily. The tendency of modern logging is to make conditions even less favorable for reforestation than did the logging of the early days.

Douglas fir and its associates are exceedingly virile and prolific, resistant to most of the enemies of forest trees, and would be quite able to perpetuate themselves, even in spite of most destructive methods of logging, were it not for uncontrolled fires. The growing of continuous crops of timber then hinges very largely upon the fire problem, with which most of the essential requirements hereafter given have to do. Fire prevention activities are of two classes -- first, control of fire in logging works, a problem for the operator to handle himself, and second, the protection of the forest land at large, which can be accomplished only by broadspread cooperative organizations.

The specific measures for keeping forest land productive are as follows:

1. Care of the virgin forest.

Absolute prevention of fire, for all fires do some damage and are likely to develop into destructive crown fires. This will be effected by the general cooperative forest protective organization, discussed in detail later.

2. Treatment of the forest and cut-over land during logging.

(a) Direct protection - an organization and equipment for minimizing accidental fires in logging works, to be financed by the operator. Specifically and very briefly stated, its essentials are:

i. A camp fire warden in every camp of over 40 men.

ii. The camp organized for fire suppression, with rules and means of carrying them out, discipline, enthusiasm, etc.

iii. A corps of able-bodied, live patrolmen, firemen, and watchmen working under the camp warden.

iv. Spark arresters, ash pans, etc., of the proper kind always in repair. Care with oil burners.

v. Fire-fighting tools of the right kind always in readiness.

vi. Donkey settings cleared and sprinkled three times a day in dry weather.

vii. Means for getting water in pressure to every part of cut-over area on which logging lines are laid during summer, either with gravity pressure system, or pumping system and pipes, or tank cars, or track fire engines, or portable pumps, and in any case abundant hose.

(b) Fireproofing cut-over land - the inflammability of an area can be lessened so that the chances for controlling accidental fires are better if the following precautions are taken:

i. Burn the slash promptly and carefully. (See Below.)

ii. Practice close utilization to minimize the amount of combustible material left on the ground.

iii. Fall all snags over 15 feet high within 150 feet of donkey settings and 100 feet of railroad tracks, and all over 30 feet high and 20 inches in diameter anywhere on the area, prior to the first slash-burning season after logging.

iv. Burn debris resulting from clearing rights of way before road is used in dry season.

(c) Prompt and careful slash burning. Burning of slashings is desirable and is required by law. Broadcast burning is the only practicable method, but this work must be done with care and at the right time. Preparations must be made in advance and given as serious consideration as any other phase of the year's logging. Plan to burn each spring and each fall so as to always keep the area of accumulated slash as small as possible. The execution of the burning should be done with intelligence and care - lay out the area with thought of topography and natural firebreaks, have the slash at the right stage of dryness, choose the right day and the right time of day, have plenty of men to act rapidly in setting the fires and set them on the proper sides first, have equipment and a crew in readiness in case the fire gives trouble, watch the area until danger from it is passed, and in the case of spring burns put out lingering threatening fires.

(d) Seed trees give added assurance of satisfactory reforestation and where there are defective trees that might be left without inconveniencing the logging or causing monetary loss, they should be left up to two per acre. Seed trees are not perhaps an essential requirement but are very desirable.

3. Treatment of the New Forest Crop after Logging.

(a) Fire prevention is the foremost and practically only care the new crop needs. It will be effected by the regional protective organization discussed later.

(b) Other considerations. As forestry practice becomes more intensive, thinnings may be made in second-growth timber, thereby stimulating growth and reaping an early income. Grazing is also suggested as a practice which, if properly regulated, may bring in a small annual return without detriment to the oncoming crop.

Considering now the general cooperative forest protective measures of the region at large, it appears that the present organization is excellent and needs chiefly intensification to make it quite ideal. There is spent now on private and State lands 3 to 4 cents on the average an acre, of which 70-80 per cent comes from private sources and the rest from the State and Federal Governments. In spite of the present system, altogether too large an acreage is burned and too much damage is done. Over a million dollars of preventable direct damage is done nearly every year, and in bad years much more. Most of the fires are caused by human agencies, hence controllable.

What the present protective system particularly should have is:

1. Protection of cut-over land and young growth for their own sakes, and not merely as an incident to the safeguarding of virgin timber. Protection should be gauged not wholly on the concrete values at stake, but should take into consideration the relative inflammability, risk and accessibility which go to make up hazard.

2. Preventive work should be strengthened. Too much goes now for fire suppression. More on prevention will save on fire-fighting bills and fire losses. There should be stricter law enforcement. Wardens should be put on earlier so as to prepare for the danger season. Fire traps should be eliminated.

3. More money must be spent for general protection. Land not now carrying its share of the burden should be assessed and the lands already contributing should pay about another cent per acre. With these additional funds, effectively spent, forest investments in both old and young timber would be reasonably safe.

4. The present State forest protective laws need modification or strengthening in a few minor matters.

Returns and Costs. The forests of the Douglas fir region grow very rapidly and yield well in comparatively short periods. On good quality sites 100-year-old timber should yield 90,000 board feet or 15,840 cubic feet, and in 60 years 39,500 board feet, or 9,720 cubic feet. Assuming such stumpage values as will prevail in the future, the monetary return per acre is considerable.

The cost of carrying out the recommendations made above and realizing these promising returns is not large. It is estimated that it will cost the average operator over and above what he now spends about 16 cents per M. feet logged during the year to carry out these essential requirements and to thus become reasonably certain of keeping his lands continuously productive.

## Digest of Desirable Forestry Practice Report for the Douglas Fir Region

Thornton T. Munger

The prescription for desirable forestry practice in the Douglas fir region may be summarized as follows:

### Care of the Virgin Forest

General cooperative fire protection along the lines now in effect, but more intensive. Protection should be afforded all classes of land according to their hazard, with special attention to cut-over land and second growth. More effort should go on prevention and less will be needed on suppression. A larger expenditure for protection than at present is needed. The fire laws must be strengthened in a few particulars.

Treatment of the Forest and Cut-over Land During Logging

(a) Direct protection is very important during logging operations to protect the land being cut over and that immediately contiguous from the special severe hazard. The following are the most important phases of logging camp fire protection:

i. Fire chief in each camp who is responsible for fire matters.

ii. Organizing every logging camp for fire suppression, and instruction in fire prevention.

iii. Firemen, watchmen, patrolmen in plenty to work under the fire chief.

iv. Escaped sparks from all kinds of engines to be carefully guarded against. Outside exhaust on all donkeys.

v. Fire-fighting equipment to be stored at strategic places.

vi. Donkey engine settings to be cleared of inflammable material and sprinkled three times a day during the danger season.

vii. Water in quantity to be available on every part of the cut-over area to which lines are extended during the fire season.

(b) Fireproofing cut-over land.

i. Burning the fresh slash broadcast immediately after logging, spring and fall, when conditions are right, using care to control the fire and get a successful burn.

ii. Close utilization to get the fullest use out of the timber and leave the minimum of combustible material on the ground.

iii. Snags over 15 feet high anywhere on the area to be felled.

iv. Unmerchantable living trees which are not needed as seed trees which might be a fire menace after the slash burn, to be felled prior to the slash burning.

v. Debris resulting from constructing railroads and roads and for a distance on each side of the right of way to be piled and burned.

vi. Fire lines to be constructed in certain places where their probable value during slash burning on subsequent protection would justify their expense.

(c) Provision for Assured Reforestation through Seed Trees or Planting.

i. Douglas fir seed trees of low merchantable value should be left wherever there are such trees as an insurance against accidental fires. Where the leaving of seed trees would involve too large an investment, planting may become necessary if natural reproduction should fail or be wiped out.

Treatment of the New Forest Crop after Logging

(a) Fire protection, such as that given to the virgin forest, is most important, and will be handled under the general cooperative protective organization for the region. Due to the high hazard of freshly cut-over land, protection must be extra intensive here.

(b) Thinnings may become profitable economically in a few decades and are desirable silviculturally, but are not now a current problem in Douglas fir management except perhaps in farmers' woodlots.

(c) Grazing will perhaps be a feature in the handling of land for a few years after logging, and is on the whole a desirable practice if properly regulated.

The cost of the minimum requirements for the average operation is placed at 15-3/4 cents per each thousand feet of logs cut over and above customary current costs; it may be considerably more than this under certain conditions, and on other operations where intensive protection is now in effect it may be less than this amount.

The additional requirements listed in this report as desirable forestry practice are very variable because of the range of forest conditions. There may be many or no unmerchantable trees to fell, seed trees may represent no capital investment or a considerable investment. It is, therefore, hard to give an average figure as to what desirable forestry practices will cost; each job must be estimated separately. In some places the desirable practice would cost hardly any more than the minimum requirements would cost. As a rough estimate, the carrying out of the recommendations of this report should not cost over 25 cents per M. feet cut, assuming 40 M feet per acre. Where the cost would be more than this, consideration should be given to modifying the prescribed measures for that case.

The most abused and denuded cut-over land resulting from present methods can be artificially reforested for $10 per acre, or 25 cents for each thousand feet cut. Besides which there would be the cost of fire protection and fireproofing, for such artificially reforested land would not be safe from fire and comparable with land naturally reforested and protected according to the recommendations of this report unless the snags were felled and the area otherwise fireproofed and protected from the menace of fire on adjoining logging operations. In other words, 25 cents for each thousand feet cut or $10 an acre should care for fire protection during and after logging, "fireproof" the area and secure natural reproduction. If artificial reforestation must be resorted to it will cost perhaps $10 an acre, besides the charges for putting the area in safe condition for planting and protecting it.

## Points of Difference Between Recommendations for Minimum Requirements and Desirable Practice

The recommendations for desirable forestry practice depart from the recommendations in the minimum requirements report in only a few particulars, none of them radical. For the sake of clarity, they are reviewed here.

1. Every logging camp of over 30 men (instead of 40) to have a Camp Firewarden.

2. Logging operations to have one fireman, besides the Camp Warden for each 30 M feet cut daily during the fire season (instead of each 40 M feet as in the Minimum Requirements).

3. Outside exhaust recommended for all donkey engines.

4. More emphasis placed on the desirability of spring burning in contrast to fall burning for silvicultural reasons.

5. All snags over 15 feet high to be felled, instead of only those over 30 feet high and 20 inches in diameter and those near donkeys and railroads, as in the minimum requirements report.

6. Unmerchantable living trees which might be a fire menace after being killed by the slash fire to be felled prior to burning.

7. The cleaning up of the debris resulting from railroad and road construction through logging areas emphasized.

8. Fire lines recommended under certain circumstances.

9. The leaving of seed trees compulsory wherever there are trees which may be left without tying up too large an investment.

10. Artificial planting recommended where natural reproduction fails.

11. Thinnings urged as desirable silviculture as soon as they are economically feasible.

12. Grazing to be allowed only where its advantages surely outweigh its disadvantages.

## Digest of Report on Devastated Lands for the Douglas Fir Region

Julius F. Kummel

Because of the readiness with which reproduction comes in naturally if given a fair chance, much of the burned area and, to a lesser extent, a considerable part of that cut over does not come within the classification of devastated lands as defined in this report.

Repeated burning is the major cause for devastation; methods of cutting are minor agencies only.

Devastated lands where satisfactory reforestation may be expected within twenty years if given protection from fire, are of the following kinds:

(a) Areas reburned only once, or possibly a second or third time; sufficient stored seed escapes to restock area slowly.

(b) Areas repeatedly burned, but which have an adequate number of seed trees left; seed trees depended upon for reproduction rather than stored seed.

(c) Burns in second growth timber which has reached the seed bearing age, but has not yet produced many, or large, crops of seed.

The total acreage of cut and burned over lands in some stage of fairly satisfactory restocking and needing only protection from fire is placed at 6.7 million acres. This figure, however, includes much land which reproduced promptly and which is not strictly "devastated" in the sense used in this report. It is not possible to segregate the latter.

Devastated lands on which satisfactory reproduction cannot be expected within a 20-year period are those which have repeatedly burned within periods too short for the accumulation of stored seed and which are practically devoid of seed trees. The number of fires necessary to cause this degree of devastation varies greatly with conditions. Estimated acreage in this class is placed at one half million acres. A greater proportion of the total cut-over acreage falls in this class than of burned areas because cut-over lands are ordinarily located closer to sources of fire.

Planting rather than seeding is recommended for the reason that the latter is too uncertain in its results.

## Digest of Public Requirements Report for the Western Yellow Pine Regions - Northern Division

R. H. Weidman

### The basic silvicultural facts

#### Reproduction

1. Yellow pine regenerates itself best by advance reproduction. It requires 10 to 30 years for an adequate cover of advance reproduction to become established under the virgin forest. Ordinarily in this region satisfactory regeneration is accomplished in a little less than 20 years.

2. Except for occasional fail years, yellow pine seed is produced in small amounts from year to year, but good seed years occur at intervals as great as 5 to 8 years.

3. Seed is largely consumed by rodents, so that after an ordinary seed year only a small surplus is left for germination.

4. Following germination there is a heavy mortality, chiefly due to severe drought and killing frosts. This loss is astoundingly heavy at first and has been observed on sample plots to amount to as much as 10 per cent in the tenth year after germination.

5. It is the slow accumulation of survivals from year to year that must chiefly be depended upon for a crop of reproduction. This is the reason for the long period of regeneration.

6. Where there is no advance reproduction or where it has been destroyed by fire after cutting, the new crop must be started by a much smaller seed supply. Only a few scattered trees left in logging are available as compared with the full overwood before cutting. There is no diminution of the forces inimical to establishment, and therefore the

period of regeneration is much longer than in the virgin forest. With 4 or 5 seed trees per acre it has taken numerous areas studied 20 to 40 years to establish a minimum cover of reproduction.

7. Although advance reproduction is abundant in this region, it does not everywhere completely stock the ground. Seed trees are necessary to fill out the blanks.

8. In the pumice soil region south of Bend, Oregon, there is a notable lack of reproduction, and in the case of this special local condition the causes and therefore the remedies are not yet thoroughly understood.

9. Fire is the worst enemy of reproduction, and the effect of a broadcast slash fire is to destroy the entire cover of advance reproduction.

10. Grazing does not do serious damage to reproduction in this region except in a negligible way.

11. Regeneration takes place more promptly in the larch-fir type and is not a problem.

Seed Trees

1. Seed trees in the yellow pine type are necessary both as an insurance against fire and to fill out understocked ground.

2. In this region yellow pine trees do not become effective seed producers as a rule until they reach a size of 17 inches d.b.h.

3. A seed tree of 27 inches produces about four times as many cones as one of 17 inches.

4. A minimum of 4 seed trees per acre of 17 inches and larger have produced at best 1,000 seedlings per acre in 20 years on old cut-over areas studied. A cover of 1,000 seedlings in this case is not as desirable a condition as would appear to one unacquainted with the situation.

5. It may be stated approximately that the cone production of four 17-inch trees equals that of three 20-inch trees, two 23-inch trees and one 27-inch tree.

6. The virgin yellow pine forest in this region contains about 6 trees per acre between 17 and 20 inches d.b.h.

7. Seed trees and other smaller trees remaining after cutting make an unusual increased volume growth due to the great liberation from competition they have received. This accelerated growth takes place for 20 to 25 years and often reaches a rate 200 to 300 per cent faster than the growth before cutting.

8. In special cases on old cuttings up to 15 years old, regeneration has taken place to but a meager extent or not at all, despite the presence of good seed trees. Rodent consumption of seed seems to be the critical factor here. It is a case apparently of a disturbance of the biological balance in which an attractive rodent food supply is reduced by logging without an accompanying reduction in the number of rodents. Poisoning during a good seed year would overcome this difficulty.

9. Both the power and horse logging methods practiced in this region do not ordinarily do serious damage to seed trees or reproduction, with the possible exception of a modified high lead system used with a skidder in central Oregon. Real high lead systems used immediately across the line in California accomplish great destruction and are incompatible with continuous forest production.

Slash

1. Broadcast burning of slash results in practically complete devastation. It is absolutely detrimental to continuous forest production.

2. Piling and burning leaves cut-over ground in the best condition for regeneration. It is costly and, if not executed carefully, may have as dangerous results as broadcast burning.

3. Previous to the enactment of State slash disposal laws, slash was left to decay on the ground. On many thousands of acres of old cut-over land in the yellow pine type, slash thus left has decayed and entirely disappeared and no fire has ever burned over the ground. It is carefully estimated that over 85 per cent of the old cut-over land in this region has escaped fire, despite the absence of protection.

4. The period of highest inflammability of slash is passed in 4 or 5 years after logging when the needles have dropped and the branches have been mashed down by snow and broken apart by grazing stock.

5. After further decaying, breaking and scattering, the slash is reduced as a special fire menace by 10 or 12 years after cutting.

6. Slash has not been a breeding medium for bark beetles. There is no evidence of any unusual insect attack upon seed trees as a result of the slash left on the old cut-over land of this region.

7. There is no effect of slash in hindering the growth of reproduction that is worth mentioning.

Effect of Fire

1. Even a light ground fire kills young reproduction. Thus, owing to the long period of restocking, to destroy the embryo second crop after cutting is to interrupt the full productivity of the land for 40 or 50 years.

2. An uncontrolled slash fire often destroys most of the remaining trees as well as the reproduction. The destruction, therefore, is the more complete because the source of seed is destroyed.

The Proposed Public Requirements

1. With regard to logging methods: Power logging methods as destructive of reproduction and remaining trees as are those using high lead yarding and high speed machines should not be allowed.

2. With regard to seed trees: In the yellow pine type at least 4 seed producing trees per acre of a minimum diameter of 17 inches at breast height should be left as insurance against fire and for filling out understocked ground. In the absence of trees within these limits, their seed producing equivalent should be left in the form of three 20-inch trees, two 23-inch trees or one 27-inch or larger tree per acre. The total volume of the seed trees left will average about 1,000 board feet an acre.

It is desirable to leave also trees smaller than those of seed tree size, i. e., trees between 12 and 17 inches. These help to make a complete ground cover. As they are at the period of their most rapid volume growth they will make for an early return cut on the area.

In the larch-fir type a number of seed trees are being left voluntarily along with the small understory trees because it is unprofitable to log all species in the type at present. In the event of heavier cutting a minimum of 2 seed trees an acre at least 18 inches in diameter of larch or Douglas fir should be left.

3. With regard to slash disposal: Slash may be left lying on the ground, provided that along roads, trails, railroads and other lines and points of fire danger it be piled and burned to a width of 100 feet each side of main lines of danger, such as roads, and 50 feet each side of trails, and at least 100 feet around camps, donkey settings, log landings, etc.

In addition, the cut-over area on which slash is left in this way should be divided into blocks of about 100 acres by strips 100 feet wide on which the slash should also be piled and burned.

Snags should be felled on all strips on which the slash is piled and burned.

Special fire protection should be given the cut-over area for 10 or 12 years, or until the slash is reduced to a condition of comparatively little fire danger.

This method of leaving slash may be practiced in all the types and generally in the region with the exception of northern Idaho and western Montana, where slash should be piled and burned because of the unusually great fire danger of this locality. This will be in keeping with the piling and burning that will be proposed for the prevailing white pine and mixed coniferous types, which entirely surround the small bodies of yellow pine of this section.

4. With regard to protection: In addition to the special fire protection to be given cut-over land for 10 to 12 years after logging, the system of protection should be such as to preserve the reproduction at all times; before, during and after cutting. This means absolutely no light burning of the ground in the virgin forest and no broadcast burning of slash after logging. It means also special measures of prevention and great care in the use of fire during the logging operation. It means a system that will detect fires quickly, will reach them promptly and will extinguish them while they are small.

## Digest of Desirable Forestry Practice Report for the Western Yellow Pine Regions
## Northern Division

R. H. Weidman

### A. Logging

1. Power logging methods as destructive of reproduction and remaining trees as are those using high lead yarding and high speed machines should not be allowed.

2. Donkey logging with ground lead yarding using a moderate line speed is compatible with desirable forestry practice if used with reasonable care.

3. Carefully practiced caterpillar tractor logging may be used.

4. Animal logging with bummers and big wheels is preferable to all other methods.

5. Wherever remaining trees are used to support blocks and rigging, they should be protected by lagging. As far as possible rigging should be slung on stumps or trees to be removed.

6. Blocks should be placed where necessary to avoid pulling through groups of young trees to be left or through patches of reproduction.

7. Care should be used to avoid falling trees into groups of remaining trees or into patches of reproduction.

8. In big wheel yarding, care should be exercised to avoid making roads through areas of established reproduction.

B. Cutting

1. The aim of cutting in the yellow pine forest should be to harvest the mature crop in such a way as to provide for the best development of young growth, whether that be advance reproduction or young trees of the bull pine class.

2. In the prevailing condition of the virgin forest, which contains many old trees, few young trees and an abundant advance reproduction, cut heavily, leaving scattered seed trees. The object is to release the reproduction and promote its rapid development as a second crop.

3. In the condition of the virgin forest which contains a representation of bull pines, follow a partial cutting method, leaving the smaller trees along with the prescribed seed trees. The younger trees are making very rapid volume growth and it would be comparable to sacrificing a high interest-producing investment to cut them.

4. Four yellow pine seed trees 22 to 24 inches d.b.h. should be left per acre. If these are not present, their seed-producing equivalent in six 20-inch trees or eight 17-inch trees should be left. In the absence of these, 2 trees 26 to 28 inches may be left. The total volume of seed trees will range between 2,000 and 2,500 board feet an acre.

5. Where it may be desired to practice a partial cutting method leaving as much as 20 to 25 per cent of the original stand, the reserved trees should be evenly spaced so as to get the greatest liberation and thus the greatest acceleration of volume growth.

6. The remaining trees should be carefully selected for their capacity to produce seed and make good increased volume growth. Thrifty young trees of long, dense, pointed crowns are the best.

7. Do not leave spike topped, diseased, badly mistletoed, and insect infested trees. Do not leave trees that will interfere with approved logging practice.

8. Where windfall is a constant danger, do not leave very tall trees with large crowns. Unusual care should be taken to leave only the most windfirm trees in shallow and moist soil and in saddles.

9. Avoid making openings of over 3 acres without seed trees.

10. In the larch-fir type a number of seed trees are being left voluntarily along with the understory trees because it is unprofitable to log all species at present. In the event of heavier cutting, 4 seed trees an acre, at least 18 inches d.b.h. of larch or Douglas fir should be left.

C. Slash Disposal

1. Broadcast burning of slash should not be done in any of the types of this region.

2. Pile and burn is the slash disposal method of first choice and should be the practice wherever the growth conditions warrant the private owner to grow a second crop. Where piling and burning is not done with great care, the results approach those of broadcast burning.

3. Over much of the yellow pine region, however, a less costly method will be imposed. The method of second choice is that of leaving slash on about 80 per cent of the cut-over area and giving the area special fire protection for 10 to 12 years, or until the slash is reduced to a condition of comparatively little danger.

4. A necessary part of the latter method is to clean up the slash along roads, trails, railroads and other lines and points of fire danger. This should be effected by piling and burning all the slash 100 feet each side of roads and railroads, 50 feet each side of trails, and 100 feet around camps, donkey settings, log landings, etc. On these cleared strips and spots all snags should be felled.

5. Another necessary part of this method is to divide the cut-over area into blocks of about 100 acres by strips 100 feet wide on which the slash should also be piled and burned. The clean-up on these strips and on those along railroads, etc., will mean that the slash will be piled and burned on about 20 per cent of the total cut-over area.

6. The method of leaving slash with the specified safeguards may be practiced in all the types and generally in the region except that piling and burning all the slash should be done in the yellow pine type of northern Idaho and western Montana, where the fire danger is exceptionally high.

D. Fire Protection

1. In addition to the special protection to be given cut-over land for 10 to 12 years after logging, the general system of protection should be such as to preserve the reproduction at all times - before, during and after logging.

2. Because of the long period of regeneration, the most important thing in fire protection in the yellow pine region is reproduction. There must be no light burning of the ground in the virgin forest and no broadcast burning of slash after logging.

3. The general protection system should be one that will detect fires quickly, will reach them promptly and will extinguish them while they are small. For cut-over land with slash on it the organization should be such that it will be able to reach all fires within a half hour of the time they are detected.

4. The time when fire danger is greatest is during the logging operation. The utmost should be done at this time in carrying out such measures of fire prevention as the following:

a. Use of oil instead of wood as fuel on logging and other railroads. Use of effective spark arresters if oil is not used.

b. Immediate removal of slash by piling and burning on strips 100 feet each side of railroads and the felling of snags on these strips.

c. Removal of slash in the same way to a radius of 100 feet around camps and donkey settings.

d. Care in use of fire in the woods by men of the logging operation.

e. Placing responsibility for action in case of fires on certain individuals at the logging camp, sawmill, etc.

f. Properly equipped fire patrol following trains.

g. Donkey engines to be equipped with hose, buckets, pumps, and tools. Tool boxes at various central localities on cut-over areas.

Digest of Report on Devastated Lands for the Western Yellow Pine Region - Northern Division

R. H. Weidman

For the purpose of this study, devastated forest lands are lands once forested and cut or burned over, the present condition of which eliminates them from classification as continuously productive. Lands which have only a few scattered seed trees or very scattered reproduction are regarded as devastated.

This report on devastated lands applies to the region east of the Cascade Mountains in Oregon and Washington and to the region south of the Salmon River in Idaho. It will include also that portion of southern Oregon west of the Cascade Mountains, in the region of the Siskiyou National Forest, where yellow pine is found as a type.

Devastated lands may be classified into two conditions. One condition is that in which reforestation will take place naturally within a period of 20 years, provided intensive fire protection is given. The other condition is that in which artificial reforestation will be necessary.

Table 1 shows the total area of devastated lands in the northern yellow pine region by States and classified into reforesting and non-reforesting conditions. The reforesting area, i. e., that which will come back naturally within 20 years, amounts to 71 per cent and the area which will need artificial reforestation amounts to 29 per cent of the total acreage of devastated forest lands of the region.

Table 1.

Total Area Devastated in the Region

| Location | Will reforest naturally | Artificial reforestation necessary | Total acreage devastated |
|---|---|---|---|
| Oregon | 550,000 | 624,000 | 1,174,000 |
| Washington | 1,635,000 | 397,000 | 2,032,000 |
| Idaho | 350,000 | 5,000 | 355,000 |
| Total | 2,535,000 | 1,026,000 | 3,561,000 |

For Oregon and Washington the area of devastated lands can be shown by private, State and Federal ownership. This information is available from the statistics recently compiled for the senate select committee on reforestation.[1] For Idaho information on ownership of devastated lands is not available.

[1] "Forest Figures for the Pacific Coast States" compiled by State, private and Federal agencies.

Table 2 shows for Oregon and Washington, according to ownership, the devastated lands which will restock naturally in 20 years, given intensive fire protection.

Table 2.

Devastated Acreage which will Reforest Naturally in 20 Years

| Location | Private | State | Federal | Total |
|---|---|---|---|---|
| Oregon | 400,000 | 2,000 | 148,000 | 550,000 |
| Washington | 640,000 | 18,000 | 977,000 | 1,635,000 |
| Total | 1,040,000 | 20,000 | 1,125,000 | 2,185,000 |
| per cent | 48 | 1 | 51 | 100 |

Table 3 shows for Oregon and Washington, according to ownership, the devastated lands on which satisfactory reproduction cannot be expected within 20 years.

Table 3.

Devastated Acreage on which Artificial Reforestation is Necessary

| Location | Private | State | Federal | Total |
|---|---|---|---|---|
| Oregon | 74,000 | 1,000 | 549,000 | 624,000 |
| Washington | 300,000 | 2,000 | 95,000 | 397,000 |
| Total | 374,000 | 3,000 | 644,000 | 1,021,000 |
| per cent | 36.7 | 0.3 | 63.0 | 100 |

These figures for acreage of devastated lands, of course, are estimated. The classification into acreage which will restock naturally and that which will not is based entirely on the figures prepared by the several agencies for use of the senate reforestation committee. These figures are the only ones available for classifying devastated land into restocking and nonrestocking conditions. The definition of the class which will restock naturally is probably much broader than the forester's definition of it. Taken from the statistical compilation, the definition of this class is "cut or burned over in some stage of fairly satisfactory restocking and needing only fire protection." Whether devastated land in this condition can be expected to reach a satisfactory state of productiveness in 20 years is a serious question so far as the yellow pine type is concerned. Ordinarily, with no reproduction on the ground it requires 20 years for 4 or 5 good seed trees per acre (17" minimum diameter) to establish 1,000 seedlings per acre on the ground. Where there are only 1 or 2 cull trees an acre which

escape a devastating fire, the period required to bring the land back to a comparable state of production may be as long as 40 years. There is no way, however, of stating the possibilities more definitely. The statement as shown in the tables that 71 per cent of the devastated lands of the region will come back to productiveness in 20 years must be accepted as a rather optimistic estimate of the situation.

The best method of bringing about artificial reforestation on the acreage which will not come back naturally is by planting nursery-grown stock. Because of the consumption of seed by rodents it is believed that direct seeding would have a very slight possibility of success in the yellow pine region.

## Digest of Public Requirements Report for the Western Yellow Pine Regions - California Division

S. B. Show

### I. Basic Silvicultural Facts

1. Seed is not stored in duff.

2. Seed production is irregular, mortality of seedlings very high, and restocking of cut-over lands with seed trees present will take from 10-25 years after cutting.

3. Preservation of advance reproduction, which is generally present, is most effective and safest way of continuing the forest, but will not give reasonably complete stocking over large areas, and must be supplemented by seed trees, both for total blanks and for filling in partly stocked areas.

4. Advance reproduction in mixed stands has higher percentage of tolerant fir and cedar than intolerant and more valuable pines, consequently new forests will have higher percentage of tolerant species than virgin forests.

5. Trees of 18-20" d.b.h. produce more seed per unit of merchantable volume than larger trees and are present in sufficient number to provide for about 85 per cent of areas, except in East Side yellow pine type. About four small seed trees per acre are sufficient for restocking cut-over areas.

6. Small trees of all species are susceptible to fire.

7. Slash does not need to be disposed of because of direct influence on advance or new reproduction as a source of insect or fungous epidemics. It ceases to be a special fire menace in about 10 years.

8. Seedlings of all species, particularly yellow pine, demand nearly full light for best development and grow poorly under shade.

9. Destruction of reproduction and seed trees leads to occupation of land by worthless brush, and reforestation of brush fields either naturally or artificially is far more difficult than for recently cut-over lands.

II. Present Destructive Practices in Cutting

1. In all stands the pines are generally cut to a diameter lower than seed production size, and in many cases firs and cedar as well.

III. Present Destructive Practices - Logging

1. Logging methods that destroy advance reproduction and potential seed trees are in general use, i. e., the high lead and high speed power logging.

2. Ground lead or modified lead logging do not in most cases devastate lands, but are more destructive than animal logging.

3. Logging, except high lead, can be regulated at slight expense so as to greatly reduce damage to seed trees and reproduction, as on Government sales.

IV. Present Destructive Practices - Fire

1. Carelessness with fire by operators and broadcast burning of slash are most important causes of devastation of cut-over lands. Most fires start on restricted areas along railways and roads and around camps and donkey settings.

2. Fires in slash are difficult to control and are exceedingly destructive. Standing snags are a serious menace.

3. Careless piling and burning approximates broadcast burning in its results.

4. Fires on cut-over lands can be held to a reasonable minimum acreage at relatively small cost, even if most of the slash is left on the ground.

V. Necessary Changes in Present Practice, i. e., Public Requirements

A. Logging

1. To preserve advance reproduction and seed trees discontinue use of high lead method and of high speed machines. Ground or modified lead satisfactory.

2. Use animal logging on ground adapted to it in place of power logging.

3. Regulate logging to minimize damage to reproduction and seed trees.

B. Closeness of Cutting

1. To restock ground and as insurance against fire cut to a diameter limit of 20" for all species. Where no small seed trees are present, larger trees should be left at the rate of 1 per acre.

C. Slash Disposal and Fire Protection

1. In order to preserve advance reproduction before, during and after logging, and to preserve adjacent virgin forests, there should be systematic protection of the virgin forest, no broadcast burning of the virgin forest or cut-over lands, care with and control of fire during logging.

2. The protection system in virgin forest should cost $.03 to $.04 an acre and year, including improvements.

3. In conduct of logging the following are essential: use of oil as fuel where possible, use of efficient spark arresters, clearing around camps and donkey settings before occupation, supply of tools for fire purposes, hose and pump at engines, designation of specific individuals charged with responsibility for fire protection.

4. Currently with extension of railroads, strips 100 feet wide each side should be cleared of inflammable material. Additional cleared lines to be constructed to divide area into small topographic units. Snags to be felled on cleared lines and for 100 feet each side. Slash to remain except on cleared lines.

5. Special patrol should follow all trains and cover cut-over areas until slash is reduced to normal, coupled with lookout and telephone service where needed. This protection designed to catch fires small and will cost $.06 to $.08 an acre and year.

## VI. Extra Costs of Proposed Measures

### A. Utilization

1. Destructive logging methods are generally no cheaper than ground or modified lead. Are favored because easier on loggers and require less intelligence in planning layout.

2. Animal logging cheaper on good ground than power logging.

3. Small trees up to 20" d.b.h. are logged and manufactured at a loss.

4. Regulation of logging, such as setting of blocks to preserve reproduction, will cost a little.

### B. Slash Disposal and Protection

1. Systematic protection of virgin forests is general in order to preserve stumpage investment.

2. Systematic protection during logging operation and after is cheaper than occasional large and costly fires.

3. Partial slash disposal and intensive patrol cheaper than piling and burning and seems to be adequate.

4. The practices recommended are mostly good business merely from the standpoint of present costs. A cost per M of $.50 to $.75 may possibly, but not probably, be necessary to cover cost of all proposed measures.

## VII. Practicability of Measures

1. Every step proposed is in use by some operators.
2. The changes recommended involve no radical departure from present measures.
3. The maximum possible cost of the measures is less than that of any one of half a dozen factors faced by the operators, such as fluctuation in price of product and of labor, efficiency of labor and machinery, etc.

## Digest of Desirable Forestry Practice Report for the Western Yellow Pine Regions - California Division

S. B. Show

# I. Limiting Factors

A. Natural

1. Preponderance of mature timber.
2. Aggressiveness of tolerant species.
3. Difficulty of securing reproduction, due to climatic factors and prevalence of brush.

B. Economic

1. Large size operations and lack of flexibility in locating cutting area.
2. Destructiveness of logging.
3. Impossibility of more than one cut on given area.
4. Impossibility of cultural operations.
5. Difficulty and cost of planting.
6. Pressure for rapid cutting and need for heavy cutting to retire investments and carrying charges.

# II. Objectives of Desirable Practice

1. To improve condition of forest by removing mature, malformed or diseased trees.
2. To preserve and release advance growth.
3. To leave a nucleus of trees for combined purpose of seed production and production of wood, so that second cut may be made in 30-60 years.
4. To reduce danger from fire.
5. To get control of soil from brush, when present, and to prevent spread of brush.

# III. Basic Silvicultural Facts

1. Seed is not stored in duff.
2. Seed production is irregular, mortality of seedlings very high, and restocking of cut-over lands will take from 10-25 years after cutting.
3. Preservation of advance reproduction is most effective and safest way of continuing the forest but will not give sufficient stocking over large areas and must be supplemented by seed trees, both for total blanks and for filling in partly stocked areas.
4. Advance reproduction in mixed stands has higher percentage of tolerant fir and cedar than intolerant more valuable pines, and consequently new forests will have higher percentage of tolerant species than did the virgin forests.

5. Seedlings of all species, particularly yellow pine, demand nearly full light for best development and grow poorly under shade.

6. Young and small trees of all species are susceptible to fires.

7. Thrifty trees of all species of blackjack type have highest capacity for profitable growth after logging, and are satisfactory as seed producers. Capacity for growth is least in flat-topped trees and intermediate in trees with rounded tops.

8. On good sites thrifty trees will after logging make 3 per cent or more interest a year in wood produced. On poor sites this rate cannot ordinarily be expected.

9. The number of thrifty trees varies greatly with site and type, being least in pure yellow pine of the East Side and greatest in the fir types.

10. Accelerated growth varies inversely as percentage of original stand left, down to about 10 per cent of stand.

11. In mixed types both white fir and sugar pine excel yellow pine in rate of growth after cutting, and sugar pine maintains a profitable rate of growth to a much higher diameter than any other species.

12. In leaving trees solely for growth the average maximum diameter of trees left should be roughly 30" for sugar pine and 24" for yellow pine and white fir.

13. The best external indices of growth capacity are character of bark and form and size of crown.

14. Thinning of reserved groups of trees is necessary to realize maximum increase of growth.

15. The best results in cutting are secured by approximately equal treatment of all species in mixed stands.

IV. Basic Facts Concerning Exploitation

1. The high lead and high speed methods of power logging are incompatible with forest production.
2. Average damage to reproduction and seed trees under similar conditions is 50 per cent less on Government than on private lands, due to inexpensive regulation of logging. Reserved trees can be protected during logging at slight additional expense.

3. Power logging is more destructive to reproduction and seed trees than is animal logging.

4. Logging methods must be judged by their effect on advance reproduction and seed trees.

5. Planting is not a simple remedy for destructive logging.

V. Basic Facts Concerning Slash Disposal and Fire Protection

1. Fire is the most important cause of devastated cut-over lands, and most fires start from the operations themselves, particularly on narrow strips along railways and roads and around camps and donkey settings.

2. Fires in slash are more difficult to control but not greatly more destructive than fires on areas where slash has been piled and burned.

3. Piling and burning of slash, if carefully and skilfully done, results in minor damage, and is the maximum that can be done to reduce hazard.

4. Fires on cut-over lands can be held to a low acreage, even if most of slash is left, and such slash ceases to be a special hazard in at least 10 years.

VI. Recommended Practices

A. Cutting

The objects of these measures are (1) to leave sufficient trees to restock the cut-over area and to combine in them ability to produce seed and to grow rapidly after logging; (2) to improve the health and rate of growth of the stand by cutting mature, defective and diseased trees, at the same time making the operation profitable. A second cut in 30-60 years is contemplated.

1. Trees to be left should be individually selected, instead of designated mechanically as in Public Requirements.

2. Reserve thrifty trees of all species of the blackjack type, unless deformed or seriously infested with mistletoe. Groups of trees should be thinned.

3. Cut merchantable trees of all species except the above, or where thrifty mature trees are reserved to avoid making large openings. Selective cutting of pine and leaving of fir, as in current practice on private lands, should be avoided.

4. Fall unmerchantable trees of all species if infested with mistletoe or fungi. Not a provision of Public Requirements.

5. In mixed stands all species should generally be treated on an equal basis.

6. Mark in reference to logging plan and to topography. Not a provision of Public Requirements.

7. The better the site the more liberally can trees be reserved. Not a provision of Public Requirements.

8. These measures contemplate the reservation of about 15 per cent of the merchantable volume.

B. Logging

The object of these measures is to preserve advance reproduction and seed trees.

1. On machines main line speed should not exceed 500 feet per minute and lead blocks should be not over 35 feet above ground.

2. Use animal logging in preference to power where possible.

3. Logging should be regulated where possible to avoid injury to reserved trees or established reproduction. Contemplates direct supervision of logging, which is not a feature of Public Requirements.

4. Layout of settings and roads should be planned to minimize damage.

C. Slash Disposal and Fire Protection

The objects of these measures are (1) to prevent fires before, during and after logging and (2) to make possible the quick control of fires that do occur.

1. Systematic protection should be given forests before cutting at an average annual cost of \$.03 to \$.04 per acre.

2. Oil should be used as fuel where possible, efficient spark arresters used on all machines, patrol should follow trains, and machines be equipped with fire tools and hose and pump.

3. Camps and donkey settings should be cleared before occupation, and watchmen provided during occupation.

4. Brush should be piled currently with logging and burned the next fall or spring and all snags should be cut. Public Requirements provide only partial disposal of slash and snags which may prove generally applicable under Desirable Practice.

5. An organization should be formed to handle fires on cut-over land within half an hour after start and specific individuals designated at each danger point to be responsible for initiating action on fires.

VII. Probable Extra Costs of Measures

A. Cutting and Logging Costs per M Feet Cut

1. Extra construction costs $.37, marking $.02, cutting diseased trees $.07, extra yarding costs $.30, supervision $.05 or a total of $.81.
2. Nominal value of 15 per cent of merchantable stand $.50.
3. Savings due to increased selling price about $.50 and decreased logging costs about $.50.

B. Slash Disposal and Fire Protection

1. Piling and burning slash . . . . . $.40
2. Clearing around settings . . . . . .02
3. Falling snags . . . . . . . . . . . .04
4. Special patrol . . . . . . . . . . .04
5. On credit side, cost of large fires $.21, plus unknown amount for equipment, timber and shutdown of operations.

VIII. Probable Returns

1. Yields
2. Intermediate returns
3. Returns from grazing, etc.
4. Rate of interest theory.
5. Trend of stumpage prices

Digest of Report on Devastated Lands for the Western Yellow Pine Regions - California Division

S. B. Show

I. Causes

1. Early fires
2. Logging and fires

II. Condition of Brush Fields due Chiefly to Early Fires

1. Total area 1,800,000 acres
2. Completely devastated - 300,000
3. Will produce only scattered forest - 300,000
4. Productive - 1,200,000

III. Condition of Cut-over Lands

1. Total cut over to date - 1,469,000 acres
2. Devastated to date - 564,000
3. Current rate of devastation 50-60 per cent of cut-over lands

IV. Treatment

1. Systematic and intensive fire protection for all lands
2. Present status of protection of brush fields - inadequate protection
3. Present status of protection of currently cut-over lands - indifference and lack of systematic efforts of many operators.

Public Requirements Desirable Practice Devastated Lands
Western Yellow Pine Region - Southwest Division
R. E. Marsh

A. Basis for Public Requirements. Determined by the following classes of factors which are of importance in the order listed.

1. Silvical facts
2. Economic considerations
3. Public sentiment

B. Regional Description. While volume of timber is small, the vast area and variety of climatic conditions involved necessitate division as follows:

1. Southwest, which for purposes of description must occasionally be divided into: a. Colorado Plateau; b. Southern Rockies, and c. Border.

2. Black Hills.

II. Determining Factors

A. Silvical facts. Three distinct types: W.Y.P. 85%, Douglas fir 10%, and Spruce 5% by volume.

1. Western Yellow Pine Type.

a. In the Southwest good seed crops occur at intervals of from 3 to 5 years, climatic conditions are unfavorable, natural enemies are numerous, therefore restocking following cutting requires 15 to 20 years. In Black Hills conditions are much more favorable.

b. In the Southwest trees 20" d.b.h. and less are of comparatively small value as seed trees. In Black Hills 14". Three to four seed trees per acre are needed where reproduction totally lacking.

c. Seed does not remain viable more than one year.

d. In the Black Hills advance reproduction almost invariably present in uncut stands. In the Southwest great variation due to artificial conditions, but naturally present.

e. Preceding conditions point strongly toward objective of advance reproduction at time of cutting.

f. Brush on the ground though usually detrimental to reproduction is not prohibitive. It is a source of acute fire danger in the Black Hills and on the Colorado Plateau which points to piling and burning. Elsewhere in the Southwest, fire lines are sufficient under the standards of Public Requirements.

g. Lightning is a prolific source of fires on Colorado Plateau. Therefore fell dead snags.

h. Normally considerable blackjack in stand and many or all age classes represented. Is therefore adapted to partial cutting system.

i. Requires from 130 to 200 years, according to locality, to reach maturity.

j. Heavy cattle grazing and sheep grazing as ordinarily carried on do serious damage to reproduction below 3 feet in height and on large areas are preventing restocking.

k. All young stuff is seriously injured by fire.

2. Douglas Fir Type

a. A mixture Douglas fir, yellow pine, spruce, white pine, white fir, cork bark fir. The first three are the most valuable and should be favored.

b. The firs and spruces are excellent seed producers, and white fir, because of this and greater tolerance, tends to crowd the others out.

c. Stand is all aged and adapted to a partial cutting system.

d. Advance reproduction is characteristically but not always present and should be preserved. Securing it after cutting is an unsolved problem, particularly for Douglas fir.

e. Fires are exceedingly destructive to all age classes and difficult to control, although they occur less frequently than in the pine type.

f. Brush is source of fire danger which in some localities is acute. It is also detrimental to the establishment of reproduction after cutting.

3. Engelmann Spruce Type

a. Advance reproduction usually present. Where absent difficult to secure, and usually only with considerable shade present. Partial cutting system indicated.

b. Spruce occurs characteristically in mixture with cork bark fir which is much inferior, but is more tolerant and easier to reproduce. Spruce should be favored.

c. Fire danger comparatively light.

d. Brush is detrimental but not prohibitive to restocking.

B. Economic Considerations

1. Forests are indispensable to the region.

a. As a local source of timber supplies. At best some lumber must be imported.

b. For watershed protection. Of special importance in a semi-arid region like the Southwest.

2. Economically practicable logging requires a cut of at least 5,000 feet per acre in W.Y.P. in Southwest and 3,000 in Black Hills. In Douglas fir heavier. In general need a cut of 75% of total volume.

3. Market demands not only lumber but hewn ties, mine stulls, and props. This means cutting some small material.

4. Rotations to produce sawlog material vary from 120 to 200 years. Yields are light. Stumpage values low. Private forestry practice unprofitable to the individual owner.

5. In the Southwest there are no examples of private forestry practice. No merchantable material is left. There is no brush disposal, but there is growing up a strong sentiment for fire suppression. It often happens that advance if protected from fire will insure maintenance of the forest. In Black Hills, Homestake Mining Company piles and burns brush. State lands are cut similar to National Forest lands.

6. 90 per cent of the timber is publicly owned (National Forests 70%, Indian reservations 18%, State 2%).

C. Public Sentiment. Supports practice of forestry on public lands. Not strong for forestry on private lands, except in Black Hills where they pile and burn brush.

## III. Public Requirements

A. Western Yellow Pine Type

1. Fire Protection

(1) An organization expenditure per acre which varies for the subregions as follows: Colorado Plateau 6 mills, Border 8 mills, Southern Rockies 2 mills, and Black Hills 15 mills. For cut-over areas the expenditure should be doubled.

(2) Use oil burning engines where possible. Non-oil burning engines must be equipped with spark arresters.

(3) Working arrangements must be made by owners and operators for fire prevention and suppression.

(4) On Colorado Plateau fell dead snags over 20 feet high.

2. Methods of Cutting

Black Hills. (1) Satisfactory advance reproduction present, no restrictions. (500 per acre over 1 foot.)

(2) Satisfactory reproduction absent, 4 seed trees per acre over 14 inches d.b.h.

Southwest. (1) At least 200 seedlings 1 foot high present either

a. 15 inch d.b.h. limit, or
b. 8 " " " " " with 2 seed trees per acre above 18 inches d.b.h.

(3) Reproduction as described above absent, leave 3 seed trees per acre above 18" with 8 d.b.h. cutting limit.

3. Brush Disposal

Black Hills. Pile and burn.

Southwest. Break up into blocks not to exceed 160 acres by 200 foot wide fire lines upon which brush is piled and burned. Pile and burn along logging roads, around camps and on other areas of special hazard.

4. Methods of Logging. In steam skidding use ground lines only with but two lines from one set. Logs to be skidded into skidder trails by horses.

5. Grazing. Exclude sheep commencing 5 years before cutting and continuing until area is satisfactorily restocked.

6. Insect Infestation. In the Black Hills control measures must be taken where epidemic conditions exist or are threatened.

7. Cost Summary

| Sub-region | Methods of cutting | | Slash disposal | Snag fell-ing | Total of logging items | Remarks |
|---|---|---|---|---|---|---|
| | Req'mt | Cost | | | | |
| Black Hills | (1) | | $3.00 | -- | $3.00 | Will apply 90% area |
| | (2) | $2.35 | 3.00 | -- | 5.35 | |
| Colorado Plateau | (1) a | -- | 1.05 | .30 | 1.35 | Will apply to large % of area |
| | (1)b | 2.54 | 1.05 | .30 | 3.89 | In hewn tie and mine prop cutting |
| | (2) | 3.84 | 1.05 | .30 | 5.19 | Around Flagstaff |
| Border and S.Rockies | (1)a | -- | .25 | -- | .25 | Will apply large % area |
| | (1)b | 2.66 | .25 | -- | 2.91 | In hewn tie and mine prop cutting |
| | (2) | 4.03 | .25 | -- | 4.28 | Applies only small % area |

B. Douglas Fir Type

1. Fire Protection. Same as for Western Yellow Pine except that snags need not be felled.

2. Methods of Cutting

(1) Satisfactory advance growth present (500 over 1 foot high per acre) a minimum diameter limit of 10 inches (not including).

(2) Advance reproduction as above described lacking either:

a. A minimum diameter limit of 14 inches (not including) or
b. Save 2 Douglas fir seed trees per acre above 18 inches d.b.h.

3. Slash Disposal

Colorado Plateau and Southern Rockies. Break up into blocks of not to exceed 80 acres by fire lines upon which brush is piled and burned. Pile and burn along logging roads, around camps and on other areas of special hazard.

Border Subregion. Pile and burn. Exception for steep slopes with high erosion danger.

4. Methods of Logging. In all types of steam skidding the outer ends of the trails must be at least 300 feet apart. Logs must be brought into the trails either by horses or right angle side haul.

5. Cost Summary

| Subregion | Methods of cutting: Req'nt | Methods of cutting: Cost | Slash disposal | Total logging cost | Remarks | Cost protection organization per acre annual: Virgin | Cost protection organization per acre annual: Cut-over |
|---|---|---|---|---|---|---|---|
| Colorado Plateau | (1) | -- | $1.05 | $ 1.05 | Covers largest % of cases | .006 | .012 |
| | (2)a) | $2.80 | 1.05 | 3.85 | | | |
| | b) | | | | | | |
| Southern Rockies | (1) | -- | .75 | .75 | Covers largest % of cases | .002 | .004 |
| | (2)a) | 2.66 | .75 | 3.41 | | | |
| | b) | | | | | | |
| Border | (1) | -- | 11.00 | 11.00 | | .008 | .015 |
| | (2)a) | 3.44 | 11.00 | 14.44 | | | |
| | b) | | | | | | |

C. Engelmann Spruce Type

1. Fire Protection

(1) Non-oil burning engines must be equipped with spark arresters.
(2) Working arrangements must be made by owners and operators for fire prevention and suppression.

2. Methods of Cutting. Cut to a minimum diameter limit of 10 inches (not including)

3. Slash Disposal. Break up into blocks of not to exceed 80 acres by 200-foot wide fire lines upon which brush is piled and burned.

4. Methods of Logging, Grazing. Insect Infestation, necessitate no public requirements.

5. Cost Summary. Data too meager to warrant estimate.

## IV. Desirable Forest Practice

A. Western Yellow Pine Type

1. Fire Protection. Same as for public requirements with added emphasis on special protection on cut-over areas. Ties in closely with brush disposal.

2. Methods of Cutting. A partial cutting system which in the Southwest will remove the overmature and mature timber except as may be needed for seed and the diseased and defective blackjack, leaving the young thrifty timber in good healthy condition for accelerated growth. This corresponds to the method in vogue on the National Forests. It is not practiced anywhere on private lands. This means two cutting cycles per rotation with some salvaging of seed trees before the end of the first cutting cycle. In the Southwest the following guides should be followed in carrying this out:

(1) Where reproduction is absent aim to save 4 seed trees per acre. (Above 20 inches per acre Colorado Plateau, elsewhere above 18"). Select blackjack where available. Number per acre may be averaged for 10-acre blocks. Reduce number seed trees in proportion to amount of reproduction already present and when reasonably suitable trees are not available. Select blackjack for seed trees when possible. Do not leave unreproduced openings over 200 feet in diameter.

(2) Cut all mature and overmature timber not needed under (1).

(3) Cut no blackjack except diseased, suppressed, and for silvicultural thinnings. Guard against leaving more than lightly infested mistletoe trees.

(4) The volume percentage removed will vary from 70% to 85%, according to conditions.

In the Black Hills an even more conservative system, which may be termed an improvement cutting, is advised. This corresponds to the local Forest Service method of cutting. It differs from the method above described for the Southwest in that healthy mature trees are retained. The method contemplates 4 cutting cycles to the rotation. It is not practiced by private owners.

3. Slash Disposal. The primary consideration is fire control. It also has considerable silvicultural bearing particularly in the Southwest, and for this reason no uniform system can be prescribed. The system advised can be best described by the following guides.

   (1) In the Black Hills, pile and burn.

   (2) On the Colorado Plateau where advance reproduction is present, pile and burn, leaving unburned, however, piles located so that to burn would extensively injure reproduction.

   (3) Elsewhere in the Southwest leave the slash either scattered or untouched but broken into not to exceed 160-acre blocks by fire lines upon which the brush will be piled and burned. On sandy, naturally open places, the brush may be left as it falls. On areas where grass and weeds grow luxuriantly, it should preferably be piled and burned. At least it should be lopped and scattered to allow grazing to reduce the competition of grass and herbage.

   (4) Throw brush in skid trails and arroyos where practicable to facilitate erosion control.

4. Methods of Logging. Same as under Public Requirements.

5. Grazing. Exclude sheep 10 years in advance of cutting and continue until satisfactory stand of reproduction above 3 feet in height is secured. Guard against overgrazing by other classes of stock.

6. Insects. Same as for Public Requirements.

B. Douglas Fir Type.

1. Fire Protection. Same as for Public Requirements.

2. Methods of Cutting.

   a. Sawlog cuttings. The aim should be to improve the stand in quality and composition, to maintain a forest cover for watershed protection purposes and to improve the rate of growth and yield. This can best be accomplished by a partial cutting system which should:

(1) Remove all overmature, mature, diseased and defective trees except

(2) On the limited areas where advance reproduction is lacking reserve 6 seed trees above 18 inches.

(3) Remove inferior species such as white fir.

(4) Open up stands more on north than south slopes to facilitate Douglas fir reproduction.

Such a system as described approximates that being followed on National Forests. It contemplates 2 cutting cycles per rotation.

b. Hewn tie cuttings. On areas handled primarily for the production of ties and miscellaneous round material cutting may be to a 14 inch limit, except where reproduction is lacking, in which case 6 seed trees above 18 inches should be retained per acre. Areas handled for hewn ties may be cut over 4 times during a rotation.

3. Slash Disposal. Is of primary importance in fire protection but it is also important silviculturally. Particularly is it detrimental to the establishment of reproduction on areas where advance reproduction is lacking. It happens that the areas of deficient reproduction and of the greatest fire danger are in the Sacramento Mountains in southern New Mexico. Here the brush should be piled and burned. Elsewhere cut-over areas should be broken into not to exceed 80-acre blocks by fire lines, 200 feet wide upon which brush is piled and burned.

4. Methods of Logging. Same as under Public Requirements.

5. Grazing. Guard against overgrazing.

C. Engelmann Spruce Type.

1. Fire Protection. Same as in Public Requirements with special protection for cut-over areas.

2. Methods of Cutting. In sawlog operations, leave all normal, thrifty, immature trees for future growth and to maintain the forest cover which is important both for watershed protection, but to maintain cover conditions favorable to the establishment of seedlings. In the cutting a minimum diameter limit of 14 inches for spruce and 12 inches for fir should be observed. In both kinds of operations larger trees should be retained when necessary to avoid openings more than 30 feet in diameter. Spruce should be favored rather than cork bark fir.

Sawlog areas may be operated on a 40-year cutting cycle and tie areas on a 30-year cutting cycle.

3. Slash Disposal. None necessary.

4. Methods of Logging. Same as under Public Requirements.

5. Grazing, Insects and Diseases. No consideration necessary other than to avoid overgrazing.

## V. Devastated Forest Lands

Includes:

1. W.Y.P. type which will not restock in 30 years.

2. Douglas fir and spruce types which will not restock in 20 years.

Devastation is due to cutting, burning or both. The bulk of yellow pine devastation is on cut-over areas. Considerable of the Douglas fir and all of the spruce is due to burning alone.

A detailed tabulation has been included in the report which shows the area divided by types, ownership, and cause, and separated into what will restock in less than 100 years and what will not. From this the following summary is given:

| | Total all types: Restock less than 100 years | Not restock in 100 years | Grand total devastated land areas |
|---|---|---|---|
| Nat'l Forest | 320,000 | 91,000 | 411,000 |
| Indian Reserv. | 216,000 | 7,000 | 223,000 |
| State | 200 | .. | 200 |
| Private | 105,500 | 94,000 | 199,500 |
| Public Domain | 250 | .. | 250 |
| | 641,950 | 192,000 | 833,950 |

Devastation has been practically stopped on National Forests, Indian lands, and State lands, but restocking on considerable old area in all classes of ownership is still being prevented by grazing. Devastation still continues on private lands.

Artificial reforestation must be by planting except possibly in the Black Hills where broadcast seeding promises success. The technique of planting to insure success has been worked out for all types. The cost will not vary greatly for the several types and will be around $75 per acre.

The high cost of planting, the comparatively low yields and the long rotations preclude private planting on a commercial scale.

Fortunately the greater part (76%) is publicly owned.

Successful planting and the natural restocking of much of the devastated area is contingent upon (1) fire prevention; (2) grazing control.

## Report of Committee on Public Requirements for Western Yellow Pine Region

The committee, consisting of Messrs. Show, Weidman, Marsh, Koch, Behre, Pearson, and Munger, met to discuss the points of difference developed in the discussion. Decisions on specific points relating to minimum requirements are as follows:

1. Width of strips to be cleared of slash can properly vary between different parts of the region due to regional differences in rate of spread of fires, amount of fuel, etc.

2. Size of blocks also permits difference between regions for the same reasons enumerated above.

3. Snags should be felled on cleared strips in all parts of the region. If additional restrictions in this respect are clearly necessary they may be allowed.

4. Intensity of patrol should, where possible, be stated in terms of hour control with an approximate cost per acre and year given. Each part of the region should also state as exactly as possible the number of years after logging during which the special intensive patrol is contemplated. If, as in the Southwest, large amounts of highly inflammable material such as grass will justify the indefinite continuation of intensive patrol, that fact should be developed in the report.

5. Logging restrictions. The two principal destructive methods in general use at present, namely, the high lead and high speed, should properly be discriminated against by means of statements defining the maximum height of block and the maximum line speed allowable. A general statement for all reports concerning the high line method is needed and it is suggested that the District 6 representatives prepare this for general inclusion in all reports. So far as possible destructive logging should be defined in terms of allowable destruction of advance growth and larger trees, stating, if that is possible, the maximum percentage of the stand which constitutes allowable destruction. This is necessary to provide for possible future developments in destructive methods of yarding. The committee agreed that exacting restrictions of the ground lead method of yarding were justified in the Southwest, but that in other parts of the region only the restrictions already in the reports are necessary.

6. Grazing. Aside from the Southwest no detailed restriction of grazing before or after cutting is justified. A general statement, however, should be included in all reports outlining the points of danger to be watched for in grazing cut-over areas. The following statement was regarded as suitable: Wherever the progress of reproduction after logging is found to be seriously retarded by grazing, effective remedial measures shall be applied.

7. Insects. For all regions a statement should be included providing for cooperation between Government, States, and private owners in case of epidemic infestations. Further than that, the committee was unwilling to go.

8. Species. In mixed stands uniform treatment of all species as contemplated in the report for the California region met the approval of the committee. This does not contemplate a requirement for heavy cutting when practice is to leave large unmerchantable trees.

9. Seed trees. The committee agreed in general to the diameter limit principle, the limit in each case to be set at seed-producing size for the particular region concerned. Where there is a clear-cut distinction between satisfactory and unsatisfactory amount of advance reproduction as in the Southwest, it was felt that some difference in seed-tree requirements was allowable. In such cases, however, of areas satisfactorily restocked, a diameter limit should be specified so that in case of fire the reserve trees would eventually take care of the area. The committee recognized that regional differences in utilization, as, for example, the cutting of mine props in the Southwest, was a legitimate reason for differences in recommendations in the different localities. It was recognized that in the California region, due to logging damage and uneven distribution of advance reproduction, no clear-cut distinction between satisfactory and unsatisfactory reproduction was desirable.

10. Desirable practice. The most important debatable point was the relative desirability of the partial cutting plan used by D-3 and D-5 as opposed to the clear cutting with seed trees proposed for D-6. The committee believed that the present methods should be retained, but that a clear statement in each report was needed to show the alternative, with best possible basis for deciding in particular cases on the desirability of each. The regulation of the cut idea should be recognized in the discussions.

11. General. The committee agreed that legitimate regional variations made it impossible to completely harmonize requirements and that it would be unwise to go farther than the recommendations set forth above.

Any differences still existing can, it is believed, be fully justified by actual and legitimate variations either in the forest itself or in methods and standards of utilization, and these differences should be explained in the final reports.

A detailed tabulation showing step by step the recommendations of the various parts of the region as agreed on is attached as part of this memorandum.

It is recommended that this memorandum be used as a basis for review by the Forester's office.

Methods of Cutting

| | Yellow Pine |
|---|---|
| D-6<br>Same for stocked and unstocked areas | Cut to diameter limit of about 18" |
| D-2<br>Black Hills<br>Reproduction present (500+)<br>Reproduction not present | <br><br>No restrictions<br>4 seed trees over 14" |
| D-3<br>Southwest<br>1. Reproduc. present Y.P. 200+ D.F. 500+<br>2. Reproduction not present | <br><br>Leave all below 16" or 2 S. per A. over 18", and all others below 9"<br>3 seed trees over 18" and others below 9" |
| D-4 | |
| D-5 | Cut to diameter limit of 20". When small seed trees are wanting leave 1 large tree (over 20") per acre. |

GRAZING

| | Yellow Pine |
|---|---|
| D-6 | Regulation in case of serious damage |
| D-2 | Regulation in case of serious damage |
| D-3 | Exclude sheep at least 5 years prior to cutting and continue until reproduction is out of danger |
| D-4 | |
| D-5 | Regulation in case of serious damage |

BRUSH DISPOSAL

| | Yellow Pine |
|---|---|
| D-6 | Left as it falls. Fire lines 100 ft. each side of roads, camps, etc. Divide cut-over lands into blocks of 100 acres by fire lines 100 ft. wide. Snags felled on fire lines. |
| D-1 | In northern Idaho and western Montana same as for D-6 |
| D-2 Black Hills | Pile and burn |

| | |
|---|---|
| D-3 Southwest | Leave as falls. Fire lines 200 ft. wide 160-acre blocks. Clear 100 ft. each side railroad, camps, roads, etc. Fall snags on cleared strips |
| D-4 | |
| D-5 | Leave as it falls except cleared lines 100 ft. each side of railroads. Additional fire lines to break area into small units. Fall snags on cleared strips. |

FIRE PROTECTION

| | Yellow pine |
|---|---|
| D-6 | Special protection of all cut-over lands. Light burning and broadcast burning prohibited. Fall snags on cleared strips. |
| D-2 | |
| D-3 | Organization and equipment similar to F.S. Cooperation with F. S. spark arresters. Operators shall cooperate in fire suppression. All snags to be felled on Colorado Plateau. |
| D-4 | |
| D-5 | Organized fire crews and equipment. Oil burners. Spark arresters. Fell snags on fire lines and 100 ft. each side. Special patrol follow trains and other special protection. |

| | Yellow Pine |
| --- | --- |
| D-6 | High lead and high speed machinery prohibited. Preserve advance reproduction. |
| D-2 | |
| D-3 Southwest | Prohibit use of high lead. Restrictions in use of low lead. Preserve advance reproduction. |
| D-4 | |
| D-5 | High lead and high speed machinery prohibited. Preserve advance reproduction. |

Report of Special Committee Consisting of Districts 1, 2, 3, and 4 Representatives on Correlation of Public Requirements Report Recommendations

## Lodgepole Pine

| | Minimum Requirements | Desirable Forest Practice |
|---|---|---|
| Fire Protection | Provide for 2 hr. control in mature stand. Provide for 1 hr. control on cut-over and reproduction areas. Suggest securing through cooperation with existing Forest Service protective organization. | Same as under "Minimum Requirements" |
| Methods of cutting | No restrictions | In general cut according to selection system taking out about 60 per cent of volume (impracticable to summarize here) |
| Brush disposal | Pile and burn around camps along roads and trails, etc. and put in sufficient additional fire lines so as to leave no areas of undisposed of brush exceeding 160 acres. This calls for piling and burning about 10 per cent of brush. | Lop tops with fire lines, as provided for under "Minimum Requirements," in Colorado and Central and eastern Wyoming. Pile and burn all brush in the remainder of the region. |
| Grazing | No restrictions | Avoid overgrazing |
| Insect control | No requirements | Undertake control work where infestations are likely to develop into an epidemic. |
| Tree sanitation | No requirements | Remove all diseased trees of merchantable size. |

Engelmann Spruce

| | Minimum requirements | | Desirable Forest Practice | |
|---|---|---|---|---|
| | Lodgepole pine region | Western yellow pine - South region | Lodgepole pine region | Western yellow pine region |
| Fire Protection | Provide for 4 hr. control in mature stand. Provide for 2 hr. control on cut-over and reproduction areas. Suggest securing through cooperation with existing Forest Service protective organization | Same as given for "Lodge-pole Pine Region" | Same as given under "Minimum Requirements" | Same as given under "Minimum requirements" |
| Methods of cutting | Leave all trees up to and including 10" d.b.h. except where thinnings are undertaken | Same as given for the "Lodge-pole pine region" | Selection system usually taking cut from 60 to 75 per cent of the volume in trees 10" d.b.h. and larger. Discriminate against inferior species such as alpine fir. Thinnings are important. | Same as given under "Lodge-pole pine region" |
| Brush disposal | Pile and burn around camps, along roads and trails, etc., and put in sufficient additional fire lines so as to leave no areas of undisposed of brush exceeding 160 acres. This calls for piling and burning about 10% of brush. | Same as given for "Lodgepole Pine Region" except that provision is made for a maximum continuous area of undisposed of brush of 80 acres instead of 160 acres | Same as given under "Minimum Requirements" except that piling and burning of all brush will be the practice in northern and western portion of region if conditions warrant | Same as given under "Minimum Requirements" |

| | Minimum Requirements | | Desirable Forest Practice | |
|---|---|---|---|---|
| | Lodgepole pine region | Western yellow pine - South Region | Lodgepole pine region | Western yellow pine - South region |
| Grazing | No restrictions | No restrictions | Avoid over-grazing | Same as given under "Lodgepole Pine Region" |
| Tree sanitation | No requirements | No requirements | Remove all diseased trees of merchantable size | Same as given for "Lodgepole Pine Region" |

| | Minimum Requirements | | Desirable Forest Practice | |
|---|---|---|---|---|
| | Lodgepole pine region | Western yellow pine - South region | Lodgepole pine region | Western yellow pine - South region |
| Fire protection | Provide for 2 hr. control in mature stand. Provide for 1 hr. control on cut-over and reproduction areas. Suggest securing through cooperation with existing Forest Service protective organization | Same as given for "Lodgepole Pine Region" | Same as given under "Minimum Requirements" | Same as given under "Minimum Requirements" |
| Methods of cutting | 1. Where stocking with immature trees satisfactory leave all thrifty trees up to and including 10" d.b.h. 2. Where stocking of tree is less than 10" d.b.h. not satisfactory leave from 3 to 5 seed trees 14" d.b.h. and larger. | Same as given under "Lodgepole Pine Region" except provision is made for leaving at least 2 seed trees which should be 18" d.b.h. instead of 14" d.b.h. | Selection system usually taking out from 60% to 75% of the volume in trees 10" d.b.h. and larger. Discrimination against inferior species such as alpine fir. Thinnings are important. | Same as given under "Lodgepole Pine Region" |

| | Minimum Requirements | | Desirable Forest Practice | |
|---|---|---|---|---|
| | Lodgepole Pine Region | Western yellow pine - South Region | Lodgepole Pine Region | Western yellow pine - South Region |
| Brush disposal | Pile and burn around camps, along roads & trails, etc. and put in sufficient additional fire lines so as to leave no areas of undisposed of brush exceeding 160 acres. This calls for piling and burning about 10% of brush. | Same as given for "Lodgepole Pine Region" except that provision is made for a maximum continuous area of undisposed of brush of 80 acres instead of 160 acres. In southern New Mexico and Arizona all brush should be piled and burned where fire conditions warrant. | Same as given under "Minimum Requirements" except that piling and burning of all brush will be the practice in northern and western portion of region if conditions warrant. | Same as given under "Minimum Requirements" |
| Grazing | No restrictions | No restrictions | Avoid overgrazing | Same as given for "Lodgepole Pine Region" |
| Tree sanitation | No requirements | No requirements | Remove all diseased trees of merchantable size | Same as given for "Lodgepole Pine Region" |

## Digest of Public Requirements Report for the Western White Pine Region

Elers Koch

I. Fire Protection

The protection standard set up is reduction of area burned over to an average of one-half of one per cent a year. To obtain this standard the following degree of protection is considered necessary:

(1) A three-hour control for uncut timber.

(2) A one-hour control for cut-over areas for a period of ten years following cutting.

(3) Areas of special hazard, such as old burns and undisposed of slash, such special patrol as the firewarden shall deem necessary.

The estimated yearly cost of this degree of protection is 8 cents an acre.

II. Silvicultural Requirements

If fire is kept out of the stand, reproduction from seed in the duff is considered sufficiently certain that no restrictions in method of cutting are set up as necessary except slash disposal measures as cited in the next section. Where larch occurs in the stand, leaving one or two larch trees per acre as an additional seed supply is desirable.

III. Slash Disposal.

Proper slash disposal is the most important and the only real essential requirement aside from general fire protection in maintaining white pine stands in productive condition. The present practice of broadcast burning is unsatisfactory because it destroys much of the seed in the duff and by killing large numbers of small and unmerchantable trees does not abate the fire danger, which becomes in a few years as great as the original slash.

Since power skidding breaks down most of the small and unmerchantable trees, separate specifications for horse logging and donkey logging are given as follows:

A. Under Horse Logging

I. Pile and burn all slash, 4 inches in diameter and under, incident to the logging operations, to a safe distance, which will ordinarily be 100 feet on each side of all railroads, roads and camps, and to a distance of about 50 feet on each side of trails and logging roads used regularly for public travel.

II. Slash along railroads, roads, trails and logging roads is to be disposed of during the first burning season following its production, which will generally be within six months.

III. Pile and burn slash on the lower one-third of all slopes, provided any burned strip is not less than 100 feet nor more than 400 feet wide and on adjacent narrow flats.

IV. On flat or gently rolling areas of considerable extent pile and burn approximately 50 per cent of all slash, such disposal to be along skidding trails to break up large areas into smaller units.

V. All other slash not covered by the above provisions is to be left undisposed of on the area.

B. Under Power Logging by Donkey Skidding

I. Burn the slash in the spring, if possible the first spring after logging. The burning is to be controlled and done under expert supervision with an adequate crew and must be localized and prevented from running generally over the area, burned down hill and against the wind. Fires must be started only in the late afternoon, unless otherwise prescribed by a competent authority.

II. Special patrol is to be given these areas for a period as long as deemed necessary by the firewarden.

The cost of complete piling and burning is about 60 cents per M. Since the specifications for horse logging provide for piling 40 to 60 per cent of the slash, the cost over the ~~xxxx~~ entire cut will be about 30 cents per M.

The cost of burning as specified for power logging is estimated at $5 per acre.

Larch-Douglas Fir Type

I. Fire Protection

The standards set up for fire protection are identical with those for the white pine type except that a four-hour control is considered adequate for green timber areas. The cost is estimated at an average of 3 cents an acre.

II. Silvicultural Requirements

There is practically always in this type sufficient reproduction on the ground, or sufficient immature or under-sized trees to form the basis for another cut or to reseed the cut-over area. Consequently no restrictions need be set up for cutting methods.

III. Slash Disposal

Broadcast burning of slash as now commonly practiced is destructive and undesirable. It destroys all the advance growth and leaves a bad fire hazard when the small and unmerchantable trees which are killed begin to fall.

The following measures are proposed for slash disposal in the larch-fir type:

I. Pile and burn all slash 4 inches in diameter and under incident to logging operations to a safe distance, which will ordinarily be 100 feet on each side of all logging railroads, wagon roads and camps, and to a distance of 50 feet on each side of trails.

II. Slash along railroads, roads, trails and logging roads is to be disposed of during the first burning season following its production, which will generally be within six months.

III. On the remainder of the logged off area the slash to be piled by the swampers as much as is practicable away from trees.

IV. The slash which is piled by the so-called swamper piling will be burned under the "selective burning" method at seasonable periods.

The selective burning of slash is a method which has already been put to use by large private operators and when done conscientiously is effective. It implies a going over the slash area two to four times to set afire isolated slash piles which will burn. The first trip is made when the slash only on the southerly exposure will burn. The subsequent trips are made to follow up the successive drying out of the forest floor on the west, east and north exposures. In this way a conflagration is prevented, as happens if the burning is postponed until slash on the northerly exposure burns readily.

The burning must be selective as to piles as well as to the time. Only those piles which are isolated from advance growth and from trees are to be set afire. Where slash lies against trees or advance growth and in burning would kill them it is to be left unburned.

The cost of complete piling and burning of slash is from 50 cents to 75 cents per M. The cost of the measures specified is estimated at 20 to 30 cents per M.

Digest of Desirable Forestry Practice Report for the Western White Pine Region
Elers Koch

I. White Pine Type

A. Protection. The protection requirements set up in the minimum requirements section are fairly adequate, and no higher standard need be set at present.

B. Silvicultural Requirements.

1. Slash disposal. The specifications for slash disposal under public requirements are somewhat of a compromise between cost and what is really needed in the way of slash disposal for an adequate degree of safety from fire. Desirable practice would provide for one of two alternatives.

(1) Pile and burn all slash with as little damage to forest conditions as possible. (2) In the case of very old overmature stands and where the amount of defective hemlock and white fir is so great as to seriously hamper white pine reproduction, fell all unmerchantable trees, broadcast slash, burn and plant the area.

The cost of piling and burning all slash will run from $.60 to $1.25 per M feet, or from $6 to $50 per acre, depending on the stand. Under the second method the actual burning of the slash should not cost over $5 per acre. Felling unmerchantable trees might range from zero to $30 per acre. Planting will average about $10 per acre.

2. Silvicultural Measures.

As a basis of description of their silvicultural treatment, merchantable stands of white pine are divided into three classes: (1) Uneven-aged stands containing in addition to the merchantable cut sufficient smaller and younger trees of desirable species to form the basis of a second cut, (2) mature, even-aged stands, (3) overmature stands.

In the first class reproduction is not aimed at, since the stand already contains the basis of a second cut. The timber should be cut to a diameter limit of approximately 14 to 16 inches breast high, the aim being to leave an even distribution of thrifty trees which will have sufficient space for good development. The stand should not be opened up enough to permit reproduction of the tolerant species, as hemlock and white fir. Species should be favored in the following order: white pine, cedar, spruce, larch, white fir, Douglas fir, hemlock.

In the second class, mature, even-aged stands, the object is to harvest the timber and secure reproduction of desirable species, particularly white pine. From two to six white pine seed trees should be left to the acre. These should be thrifty dominant or co-dominant trees, selected with reference to wind-firmness, seed-bearing qualities, and possibilities for further growth. In addition, any thrifty white pines under 14 inches with good crowns should be reserved. Also, from two to six larch or Douglas fir trees to the acre should be left for seed. Hemlock and white fir should be cut to the lowest merchantable limit.

The third class, overmature stands, is a difficult problem to handle. There are no white pine trees in such stands suitable for seed trees. Consequently, the white pine must be cut clean except for defective and worthless trees, which may be left standing for seed production. From two to six larch, Douglas fir or cedar trees may be left for seed, if suitable trees exist. White pine reproduction may usually be expected from seed in the duff.

An alternative in overmature stands is to cut all merchantable timber, fell all unmerchantable trees; broadcast slash burn and plant the area.

In both mature and overmature stands defective white fir and hemlock are frequently found in such quantity as to prevent white pine reproduction through too much shade. In such cases the defective trees should be felled and the slash disposed of by piling and burning. This is an expensive measure and may cost as high as $15 to $50 per acre.

II. Larch-Douglas Fir Type

A. Protection. The protection requirements set up in the minimum requirements section are fairly adequate and no higher standard need be set at present.

B. Silvicultural Requirements

1. Slash disposal. All slash should be piled and burned with as little damage to forest conditions as practicable. The cost will run from $.60 to $1.00 per M feet.

2. Silvicultural measures. In even-aged, mature stands, where there is no young growth the stand should be cut clean except for three to six selected seed trees to the acre, of which at least two should be larch. This will usually ensure good larch reproduction.

The greater part of the larch-fir stands are irregular in age, due to thinning from past fires. In such cases a selection cutting should be made, taking out the mature trees to a diameter limit of about 14 to 18 inches. Groups of thrifty 12 to 18-inch trees should be thinned. All badly fire-scarred or defective trees of merchantable size should be taken out. Larch, yellow pine and white pine should be encouraged, and Douglas fir cut somewhat more closely.

## Digest of Report on Devastated Lands for the Western White Pine Region

Elers Koch

### 1. Private Lands

The privately-owned forest lands in Montana and Idaho were, of course, originally pretty well timbered, and occupy the best sites, since they were largely acquired for their timber values. Devastation of these lands has occurred chiefly through a combination of lumbering and subsequent fire. It is notably true that in all types the very great majority of cut-over lands which have not been burned since logging are reproducing and in good productive condition.

It is also very obvious that the older cut-over lands are in much better condition than areas cut over in the last ten years. This may be attributed to a large extent to the general practice of intentionally broadcast burning slashings which has been followed for some years, and which is required by both the Montana and Idaho State laws. In the writer's opinion, the compliance with the slash burning laws has resulted in far more devastation of forest land than would have resulted from accidental fires starting in undisposed of slash. The greater part of the area cut over each year is now burned within one or two years following cutting, and frequently burned several times subsequently, particularly in the white pine type, where a large amount of unmerchantable trees are usually killed by the first slash fire, and form a subsequent fire menace.

The white pine type is in the worst shape of any type in the region. Not only is it being burned over as fast as it is cut, which usually results in devastation, but the older cuttings have also been badly burned, and as a result there is only a small percentage of cut-over white pine land now in productive condition.

The yellow pine type is in much better condition, since the earliest cutting was largely in this type and much of it escaped fire, and is largely reproducing. A hard slash burn in yellow pine usually results in devastation, and of recent years much of it has been so burned.

The fir-larch type withstands fire well. Some of it has been devastated by repeated fires, but if any seed trees survive, land of this type usually reseeds.

There are no adequate statistics on the area of devastated private land in either Idaho or Montana. The best estimate available, which is little more than a guess based on general knowledge by forest officers of the region, is 230,000 acres in North Idaho, and 320,000 acres in Montana. Practically all of this land may be considered permanently nonproductive without artificial reforestation. Even with adequate fire protection it would take many years before most of it would reseed naturally.

The yellow pine cut-over lands are being used to a considerable extent for grazing. The fir-larch type has little grazing value and much of the white pine type has no grazing value, though portions may be used for sheep grazing.

There seems no probability of any planting being done through private enterprise, and Federal acquisition appears to be the only hope of reforestation.

2. National Forest Lands

The statistics on devastated land on the National Forests in District 1 are but little better than on private lands. The best estimate available is 202,500 acres, of which 6,500 acres are in Montana and 196,000 acres in Idaho. This includes only areas which are possible planting chances and excludes very steep or rocky areas, or areas at high elevations which it will never be desirable to plant.

The devastated lands on the National Forests differ from those on private lands, since they are for the most part the result of fire only, rather than a combination of logging and fire.

Most of the area on the National Forests on which mature timber has burned is reproducing fairly well. The greater part of the devastated area is the result of two or more fires within an interval of less than thirty or forty years. A double burn of this character usually results in devastation and will require planting.

The present District program calls for planting about 4,000 acres a year.

Digest of Public Requirements Report for the Lodgepole Pine Region
M. W. Thompson

Status of Ownership - Timbered area of region (exclusive of National Parks) slightly over 23 million acres:

| | |
|---|---|
| National Forests | 87% |
| Public Domain and Indian Reservations | 5% |
| State | 1% |
| Private | 7% |

Forest Types: Lodgepole pine
Engelmann spruce
Douglas fir
Aspen

History of Cutting and Fire Protection: Most serious damage through cutting followed by fires occurred from about 20 to 60 years ago.

Present Cutting Practice:

National Forests - 80% or more of cut.
Generally a selection system removing from 60% to 75% of the volume in trees 10" d.b.h. and larger.

State Forest Lands:
Colorado - Trees over 10" d.b.h. cut. State plans to consolidate lands into one unit.
Wyoming - Cutting unrestricted, limited volume being cut. State exchanging forested lands for grazing lands outside National Forests.
Idaho, Nevada, Utah, Montana - Little or no cutting taking place on State lands in these States. Cutting unrestricted. States other than Montana disposing of forested lands as opportunity permits.

Private Forests:
Idaho, Nevada, Utah and Wyoming - Cutting very limited.
Montana - heavy cutting in '90s. Cutting limited.
Colorado - Cutting heavy in past and at present time.
Cutting in all States unrestricted.

Public Domain )
Indian Reservations) Cutting very limited - largely dead timber.

Brush Disposal Practice
National Forests:
Lodgepole Pine Type: Piling and burning except for lopping and scattering with fire lines in Colorado and Wyoming.

Engelmann Spruce Type: Lopping and scattering in Colorado, Wyoming and Utah; piling and burning in Montana.

Douglas Fir Type: Lopping and scattering in southern portion of region and on drier sites in Idaho and Montana; elsewhere piling and burning is the practice.

Aspen Type: Cutting limited - brush lopped and scattered to limited extent.

Other Lands: No disposition of brush undertaken except in Montana, where brush is largely broadcast and on State sales in Colorado, where a limited amount of piling and burning and lopping has taken place.

Methods of Logging - Animals

Fire Protection Practice of Region

United States Forest Service - Forest Service only fire protection agency in region except for Blackfoot Timber Protection Association.

Fire protection first duty of employees. Lookouts and patrolmen employed during periods of fire hazard in addition to permanent force.

On typical lodgepole pine areas in Colorado and Wyoming, each field employee has charge of 150,000 acres, the annual expense for fire protection and suppression averaging 1½¢ per acre.

On typical Engelmann spruce areas in Colorado each field employee has charge of 200,000 acres and annual expense averages 1¢ per acre.

"Key Men" - responsible local residents - supplement regular force, taking initial action in detection and suppression. These men are paid only when engaged in suppression work.

Above costs do not include protective improvements such as telephone lines, lookout towers, trails and roads for which necessary expenditures vary greatly. Living quarters and fenced pastures for stock are essential.

Also equipment, such as instruments for lookouts, tools for fire fighting, and in special cases light trucks, are made available.

Limited amounts of money are spent each year on publicity and educational work - an important fire protection activity.

Other Agencies - Blackfoot Timber Protection Association in Montana only private protection agency in region. Organized in 1922 for protection of timber on private and State lands, the Public Domain and a small amount of National Forest timber. This cooperative plan has not been thoroughly tried out.

Northern Pacific Railroad makes cooperative deposits on basis of Forest Service expenditures for protection of its holdings within and adjacent to Absaroka, Gallatin, Beartooth and Helena National Forests.

State of Montana plans on protecting State timberlands and private lands not so located as to be protected by other agencies. Montana only State in region with which Government cooperates under Weeks Law.

Other States are not paying much attention to fire protection.

A large portion of residents living under country conditions are cooperating effectively with the U. S. Forest Service in fire protection. Many non-resident owners of timberland are arranging to pay for the cost of protection by the U. S. Forest Service through cooperative deposits.

## I. Lodgepole Pine Type

### Silvical Data

Extensive pure stands of lodgepole pine characteristic of region, stands usually even-aged though not made up of trees of uniform size.

Species good seed producer - at least a fair crop each year, and trees begin to bear cones when about fifteen years old.

Part of cones remain unopened on trees for years after they ripen. Bracts are thick and tightly sealed with resin. This protects seed from being made sterile by fires.

Reproduction comes in on burned areas in comparatively short time; Mason's studies show that 70 per cent of reproduction on 181 plots comes in within 5 years after being burned or cut over.

Successful reproduction after fires due: (1) seed is always present when stands of cone bearing size are burned over; (2) exposed mineral soil resulting from fires makes optimum seedbed and eliminates competition.

Public Requirements

Fire Protection - An organization should be provided, as well as improvements, such as lookouts, telephones, roads and trails, and fire-fighting equipment, etc., sufficient to make it possible for at least one man prepared to fight a fire, to reach it at any point on the protected area within at least from one to two hours after the fire is discovered, as follows:

(a) A two-hour control will be maintained for mature stands;

(b) A one-hour control will be maintained for areas of special hazard such as cut-over lands where brush has been scattered and extensive areas of reproduction.

This will require an average of about one man for 150,000 acres, exclusive of lookout men, and except for the special improvements necessary, such as roads, trails, telephone lines, lookouts, cabins, etc., which vary greatly in different localities, should cost about 1½¢ per acre. This is the skeleton organization, which is based on securing cooperation from "key" men and other local residents.

All non-oil burning or non-electrically driven engines operated on or adjacent to forest lands during the fire season, which usually runs from about June 1 to October 15, should be provided with efficient spark arresters - and all non-oil burning locomotives should be provided with ash pans which will prevent dropping ashes along rights of way. Rights of way traversed by non-oil burning locomotives should be kept clear of inflammable material for a distance of 100 feet on each side of the track.

Methods of Cutting - No cutting restrictions necessary.

Brush Disposal - Pile and burn all brush, four inches in diameter and smaller, resulting from cutting operations as follows:

(a) Along railroad rights of way where fuel oil is not used, for a distance of 100 feet on each side of the right of way;

(b) For a distance of at least 100 feet around camps;

(c) For a distance of 100 feet on each side of logging roads or traveled roads;

(d) For a distance of 50 feet on each side of trails;

(e) On sufficient strips 200 feet wide, in addition to the above and taking advantage of all natural fire lines, so as to leave no continuous areas exceeding 160 acres where the brush is left on the ground.

All brush which is not piled and burned should be lopped from tops of all trees cut.

In the more hazardous portions of the region, such as in Idaho and Montana, where the plan of brush disposal provided for in the previous paragraph is insufficient to render adequate protection, the plan of requiring the piling and burning of all brush may be required.

Brush piles should be compact so that they will burn satisfactorily under snow. They should be of a size and located at a sufficient distance from standing trees so that they may be burned with a minimum amount of damage to the remaining stand. Brush disposal should be completed within one year after cutting takes place.

Grazing - Ordinarily no grazing restrictions are necessary, but number of stock, distribution and handling should be so regulated as not to impair the perpetuation of the timber stand. This means that grazing should be so regulated as not to reduce the carrying capacity of the range. If this plan is followed, damage to timber will ordinarily be negligible.

Cost Summary - The cost of public requirements in the lodgepole pine type is summarized as follows:

| Fire Protection | Method of cutting | Brush disposal | Grazing |
|---|---|---|---|
| $.015 per acre annually | No expense | From 30¢ to 40¢ per M ft. or from $3 to $5 per acre, for lopping with not to exceed 10% piled and burned. 80¢ to $1 per M ft. or from $5 to $12 per acre, and averaging about $10 per acre where all brush piled and burned. | No expense |

## 2. Engelmann Spruce Type

### Silvical Data

The Engelmann spruce type occurs in typical, uneven-aged stands naturally adapted to a selective system of cutting. This species withstands shade well, as is characteristic of other members of this genus. Seedlings persist even in dense shade and though they make very slow growth, respond quickly when released. Immature trees recover very satisfactorily after the larger timber has been removed and seed distribution begins after trees reach an age of about 25 years. Engelmann

spruce and its associated species do not bear seed as prolifically as lodgepole pine, and seed of these species is not stored up by natural means to anywhere near the extent that this is true for lodgepole.

## Public Requirements

Fire Protection - An organization should be provided, as well as improvements, such as lookouts, telephones, roads and trails, and fire-fighting equipment, etc., sufficient to make it possible for at least one man prepared to fight a fire to reach it at any point on the protected area within at least from two to four hours after the fire is discovered, as follows:

(a) A four-hour control will be maintained for mature stands;

(b) A two-hour control will be maintained for areas of special hazard, such as cut-over lands and extensive areas of reproduction.

This will require an average of about one man for each 200,000 acres, exclusive of lookout men, and, except for the special improvements necessary, such as roads, trails, telephone lines, lookouts, cabins, etc., the need for which varies greatly in different localities, should cost about 1¢ per acre per year. This is the skeleton organization, which is based on securing cooperation from "key" men and others.

All non-oil burning or non-electrically driven engines operated on or adjacent to forest lands during the fire season, which usually runs from about June 1 to October 15, will be provided with efficient spark arresters - and non-oil burning locomotives will be provided with ash pans which will prevent dropping ashes along rights of way. Rights of way traversed by non-oil burning locomotives should be kept cleared of inflammable material for a distance of 100 feet on each side of the track.

Methods of Cutting - Leave all thrifty trees up to and including 10" d.b.h. The only exception to this requirement should be where a thinning of small trees is undertaken. Ordinarily no restrictions will be necessary.

Brush Disposal - Lopping all brush from tops of trees cut should be the public requirement for the Engelmann spruce type. An exception may be made on areas of special hazard, such as certain stands in Montana, where piling and burning of all brush four inches and smaller in diameter resulting from cutting operations may be required in addition to the above as follows:

(a) Along railroad rights of way where fuel oil is not used for a distance of 100 feet on each side of the right of way;

(b) For a distance of at least 100 feet around camps;

(c) For a distance of 100 feet on each side of logging roads or traveled roads;

(d) For a distance of 50 feet on each side of trails;

(e) On sufficient strips 200 feet wide, in addition to the above and taking advantage of all natural fire lines, so as to have no continuous areas exceeding 160 acres where the brush is left on the ground.

Where piling and burning is undertaken, piles should be compact so that they will burn satisfactorily under snow. They should be of a size and located at a sufficient distance from standing trees so that they may be burned with a minimum amount of damage to the remaining stand. Brush disposal should be completed within a year after cutting takes place.

Grazing - Unimportant. See paragraph under "Lodgepole Pine Type" page 262.

Cost Summary - The cost of public requirements in the Engelmann spruce type is summarized as follows:

| Fire protection | Methods of cutting | Brush disposal: Method | Per M Feet | Per Acre | Grazing |
|---|---|---|---|---|---|
| | | Lopping | 15¢ -25¢ | $1.50 -$3.00 | |
| 1¢ per acre annually. | No expense. | Lopping with piling and burning on fire lines | 25¢ -35¢ | $2.00 -$4.00 | No expense |
| | | Piling and burning all brush | 80¢-$1.00 | $5.00 -$12.00<br>Avg. $10.00 | |

## 3. Douglas Fir Type

Silvical Data.

This type is much less important from standpoint of acreage and volume than either lodgepole pine or Engelmann spruce. It occurs in comparatively small areas toward lower limits of tree growth, except in northern portion of region. In Montana and Idaho it occurs as a distinct type over considerable areas, being of much greater relative importance there than farther south and of greater importance than the Engelmann spruce type.

Douglas fir is not a strong seeder, rate of seed germination being moderately high. Seed production begins at about 25 years of age and satisfactory reproduction usually secured on cut-over areas. If no reproduction present when cutting takes place, it may be difficult to secure it. Important that partial stand remain after cutting for shelter as well as for seed distribution. Conditions on burned areas usually less favorable to reproduction of this species than lodgepole pine and aspen.

Public Requirements

Fire Protection - Same as for Engelmann spruce. See page ~~6 and 7~~ 264.

Methods of Cutting - Leave all thrifty trees up to and including 10" d.b.h. The only exception to this requirement should be where a thinning of small trees is undertaken. Ordinarily no restriction will be necessary.

Brush Disposal - Lopping all brush from tops of trees cut should be the public requirement for the Douglas fir type, conforming with the prescribed practice for Engelmann spruce. An exception may be made on areas of special hazard, such as in certain stands in Idaho and portions of Montana, where stands are extensive and are subject to long periods of drought. There piling and burning all brush 4 inches in diameter and smaller resulting from cutting operations, may be required in addition to the above as follows:

(a) Along railroad rights of way where fuel oil is not used for a distance of 100 feet on each side of the right of way.

(b) For a distance of at least 100 feet around camps.

(c) For a distance of 100 feet on each side of logging roads or traveled roads.

(d) For a distance of 50 feet on each side of trails.

(e) On sufficient strips 200 feet wide, in addition to the above and taking advantage of all natural fire lines, so as to have no continuous areas exceeding 160 acres where the brush is left on the ground.

Where piling and burning is undertaken, piles should be compact so that they will burn satisfactorily under snow. They should be of a size and located at a sufficient distance from standing trees so that they may be burned with a minimum amount of damage to the remaining stand. Brush disposal should be completed within a year after cutting takes place.

Grazing - Unimportant. See paragraph under "Lodgepole Pine Type" page ~~5 and 6~~ 262.

Cost Summary - The cost of the public requirements in the Douglas fir type is summarized as follows:

| Fire protection | Methods of cutting | Brush Disposal: Method | Per M Feet | Per Acre | Grazing |
|---|---|---|---|---|---|
| 1¢ per acre annually | No expense | Lopping & scattering | 20¢ to 30¢ | $5.00 avg. | No expense |
| | | Lopping and scattering with piling and burning on fire lines | 25¢ to 35¢ | $2 to $4 | |
| | | Piling and burning all brush | 80¢-$1.00 | $6.00 avg. | |

## 4. Aspen Type

### Silvical Data

The outstanding characteristic of this species, as it affects forest management, is its lack of effective seeding and the large extent to which reproduction by sprouting occurs. Reproduction by this means occurs regardless of age of stand cut over and time of year cutting takes place. Since little cutting of this species occurs or is likely to take place in the near future, this type is of very minor importance.

### Public Requirements

Fire Protection - Areas should be protected and requirements outlined under Engelmann spruce type will apply.

Methods of Cutting - No restrictions necessary.

Brush Disposal - No brush disposal necessary.

Grazing - Overstocking should be avoided and stock should be properly handled and salted. In addition, sheep grazing should be excluded for about a five-year period on cut-over areas where damage is at all likely to occur. More important in this type than in any other in region.

## Digest of Desirable Forestry Practice Report for the Lodgepole Pine Region

M. W. Thompson

The object in outlining desirable forest practice for the different types in the region is to set forth the measures necessary in order (1) to maintain the production of forest lands at a point commensurate with the capacity of the land or to increase production to this point; (2) to secure and maintain a stocking of the species which can be grown to best economic advantage on the site.

For brief description of forest types, outline of silvical characteristics of species, discussion of protection, cutting and brush disposal practices, etc., see Part I of this report.

### 1. Lodgepole Pine Type

#### Fire Protection, Slash Disposal and Grazing

The requirements under desirable forest practice should be the same as those outlined in the public requirements section.

#### Methods of Cutting

Type managed principally for sawlogs and ties except in a few regions of thin soils where smaller materials will be produced. Selection or clear cutting should be practiced.

#### Immature Pole Stands

Thin and improve stands of 4" to 10" according to purpose of sawlog or smaller material production. Favor good species, cut inferior ones. For trees averaging 8" - 320 trees per acre is good spacing - in small pole stands leave proportionally more.

#### Mature or Overmature Pole Stands

These are the result of crowding on good sites or of poor site. Where marketable, cut all mature trees, favoring Douglas fir. Guard against wind-throw of reserves.

#### Tie and Sawtimber Stands

(a) Thrifty mature stands.

Remove overmature and defective or crowding trees. Favor trees with thrifty full crowns and taper, since they will produce tie timber fastest. 13" a guide to maturity - cut immature trees only to thin or to remove defective ones, or inferior species. Should remove 45 to 60% of the number of trees 10" d.b.h. and larger. Another cut in 30 to 50 years.

Cost of partial cutting will add only 15¢ to 25¢ per M ft.

(b) Overmature stands.

Majority of trees past maturity, crowns flat and sparse. Growth at a standstill. Practically clear cutting recommended except for scattered, sound, thrifty immature trees, which should be retained for growth and to insure reproduction.

Insect Control

This subject should be given further study and control measures put into effect.

Forest Sanitation

This should be a guiding object in all cutting operations.

## Digest of Report on Devastated Lands for the Lodgepole Pine Region

M. W. Thompson

These are lands that were forested but have become nonproductive through cutting and fire, or near Butte and Anaconda, from smelter fumes. About 5 per cent of the lodgepole pine forest (1,029,000 acres) estimated as devastated, 27 per cent of this in lodgepole pine type, 35 per cent in the Engelmann spruce type, and 38 per cent in Douglas fir type. Little devastation since 1905; total area decreasing.

Present Condition

Higher type grazing land. Heavy grass sod and lack of seed trees responsible for failure to recover. True lodgepole type devastated by repeated fires - now grazing land with partial aspen cover. Aspen not a merchantable crop; serves as a nurse crop.

Treatment

Natural restocking very slowly. Will not reclaim more than 20 per cent of lodgepole type in 20 years; 10 per cent of Englemann spruce type in same time. Artificial restocking needed on nearly all the Douglas fir type.

Digest of Public Requirements Report for the Redwood Region
S. B. Show

I. Basic Silvicultural Facts

1. Sprout reproduction of redwood, except rarely, is secured, regardless of manner or season of logging or slash disposal or intensity of cutting, and will form 25-35 per cent of a full stand.

2. Redwood reproduction from seed is not common and cannot be counted on.

3. Fully stocked stands of pure redwood are uncommon.

4. Desirable associated species reproduce readily from seed trees but not apparently from dormant seed.

5. Associated species are able to compete with redwood up to rotation age.

6. Advance reproduction is not a factor.

7. Slash disposal by broadcast burning is an essential protection requirement.

8. Preservation of seed trees of associated species through slash burning seems to be practicable and is necessary to secure reasonable stocking naturally.

9. Average best natural stands will be 60-80 per cent fully stocked and even-aged.

II. Destructive Agencies - Cutting

1. Clear cutting of redwood is satisfactory. Trees of doubtful merchantability of associated species are often cut too close, or are knocked down in falling operation.

III. Destructive Agencies - Logging

1. Uncut trees of associated species are destroyed to some extent by logging.

IV. Destructive Agencies - Slash Disposal and Fire Protection

1. Broadcast burning of slash now carelessly and unintelligently handled with consequent destruction of potential seed trees.

2. Repeated burning of cut-over lands in general for purposes of grazing.

3. Systematic protection of either virgin forest or cut-over land very incompletely organized.

V. Necessary Changes in Present Practice, i. e., Public Requirements.

A. Logging

1. Any method of yarding may be used, provided that uncut trees, particularly large defective Douglas firs, should be preserved.

B. Intensity of Cutting

1. Clear cutting of redwood is satisfactory. Trees of doubtful merchantability of associated species should be left.

C. Slash Disposal and Fire Protection

1. Burn slash broadcast after completion of yarding, taking precautions to preserve standing trees.

2. Systematic protection of virgin forest should be organized on 1½ to 2-hour control basis.

3. Systematic protection on cut-over lands should be on about 1-hour control basis and should begin immediately after slash disposal.

4. Reburning of cut-over lands for grazing purposes is not allowable.

VI. Practicability and Costs

1. No apparent reason why some seed trees of associated species cannot be saved through falling, yarding and slash disposal.

2. Extra costs of fire protection low and probably more than offset by savings in suppression.

3. Extra costs of preserving seed trees unknown.

Digest of Desirable Forestry Practice Report for the Redwood Region

S. B. Show

I. Controlling Factors

1. Problems of securing full-stocked stands naturally.
2. Productive capacity of lands.
3. Progressive attitude of operators.
4. Assumed ease of planting.

II. Objectives of Desirable Practice.

1. Securing fully-stocked, even-aged stands, either pure or mixed.

2. Preventing occupation of ground by brush by starting new forests immediately after logging.

III. Basic Silvicultural Facts

1. Sprout reproduction of redwood, except rarely, is secured, regardless of manner or season of logging or slash disposal or intensity of cutting, and will form 25-35 per cent of a full stand.

2. Redwood reproduction from seed is not common and can not be counted on.

3. Fully-stocked stands of pure redwood are uncommon.

4. Desirable associated species reproduce readily from seed trees but not apparently from dormant seed.

5. Associated species are able to compete with redwood up to rotation age.

6. Advance reproduction is not a factor.

7. Slash disposal by broadcast burning is an essential protection requirement.

8. Preservation of seed trees of associated species through slash burning seems to be practicable, and is necessary to secure reasonable stocking naturally.

9. Average best natural stands will be 60-80 per cent fully stocked and even-aged.

IV. Recommended Practices

1. Save seed trees of associated species as under Public Requirements.

2. Plant blanks with redwood or associated species.

3. Dangers of creating pure stands of redwood should be recognized.

4. Systematic fire protection of virgin forest and cut-over lands should be given, as under Public Requirements.

V. Probable Costs and Returns.

Digest of Public Requirements Report for the Northeast
Raphael Zon

1. Six commercial forest types are recognized in the Northeastern States:

1. Swamp type
2. Spruce-fir type
3. Northern hardwood type with admixture of white pine, spruce, and hemlock
4. White pine type
5. Southern hardwoods or sprout hardwoods
6. Yellow pine type

Also three minor types: (1) the white birch and aspen; (2) gray birch, and (3) scrub oak.

2. There is no need for any restrictions in the method of cutting in any of the six commercial types. The three minor types, particularly the gray birch and scrub oak, offer a problem in reforestation rather than in methods of cutting.

3. Special fire protection measures are necessary at the time of logging. These are; clearing of the rights of way along logging roads, highways, trails; clearing safety strips around green timber, settlers' homes, and sawmills. Other precautionary measures such as spark arresters on all engines and burning oil on all locomotives through particularly dangerous districts at certain times of the year; assignment at lumber camps of certain persons to act as leaders in organizing fire crews and similar measures now well recognized and more or less enforced in most of the Northeastern States.

4. Brush disposal from a silvicultural and fire protection standpoint is very desirable, but no State-wide compulsory slash disposal by burning is advocated.

5. There should be, and already is in most of the Northeastern States, special authority for the State Forester or a special clause in the State forest law, permitting the Forester to enforce the clearing up of certain dangerous areas either by actual removal of the inflammable material or the clearing of safety strips.

6. Lopping of softwood slash to 3 inches in the top, and of hardwood slash to 6 inches in the top is considered an essential measure.

7. General fire protective organization in the States which would provide for a permanent force for directing fire protection work in the State. Each county or more counties to be in charge of efficient permanent Forest officers. These are to direct the work within the districts

and act as inspectors with administrative power over the lookout and patrol force. In addition, there should be a temporary force employed for the fire season and organized by towns or township or equivalent units, and on an average for every 2,500 acres there should be an organized suppression force.

8. An adequate lookout and patrol force which could detect forest fires before they exceed one-tenth of an acre in size, or within 15 or 20 minutes after the fire starts.

9. The organization of a suppression force that could reach the fire after it is located before the fire exceeded one acre. No fires on an average should be allowed to exceed 10 acres in area, or in general should be allowed to run over one night. In general, an organization that could reduce the area burned over annually to from one-tenth to one-half of one per cent of the total forest area. The cost of fire protection it is estimated will be between 3 and 5 cents per acre.

10. Classification of the forest in the State on the basis of permanent forest land and temporary forest land in densely settled districts. Clear recognition of the need of a different fighting organization and different methods of fire fighting on the two kinds of land.

11. Creation of special protection forests which are to receive special fire protection from the State for which the timber owners would be willing to submit to certain restrictions in the method of cutting.

Digest of Report on Devastated Lands for the Northeast
Raphael Zon

The policy toward denuded forest land may be briefly stated as follows:

1. A careful survey of the nonrestocking area with the view of determining its condition and present and potential value.

2. A complete fire protection of denuded forest land.

3. The State should first attempt to reforest its own denuded land in need of artificial reforestation.

4. The State should select land which needs to be reforested first. It should be selected with the idea of forming large forest bodies capable of sustaining permanently, either by themselves or in conjunction with other second growth in the vicinity, wood-using industries.

5. The State should encourage, wherever necessary, planting by private timber owners through distribution of planting stock at cost, provide advice as to species, methods, and care of the plantations.

6. The State should work out a system of forest taxation suitable for encouraging growing timber.

7. Under certain circumstances the State may even lease land from private owners in case the latter are unable to do so themselves and reforest it. The owner is to retain the right to redeem the land, together with the timber on it, by paying the cost of reforestation and other charges.

## Report of Desirable Forest Practice for the Northeast

Raphael Zon

The minimum public requirements will prevent forest land after cutting becoming totally unproductive. They will not, however, secure the highest possible productivity of the land. The minimum public requirements will not balance the present discrepancy between depletion and growth. In order to bring the growth of our forests to the point where it can meet our present needs, forest practice must be developed which will go beyond the minimum public requirements.

What this silvicultural practice should be for the different forest types and forest conditions is difficult to say. Under intensive forest management a forester may use different silvicultural methods and yet attain the same result. There is no universal silvicultural method, even for the same type, which will produce the best results. The silvicultural practice must vary not only with the forest type but also with the purpose which the timber owner may have in growing this timber. If, for instance, an aspen stand is to be managed for the production of aspen pulpwood one silvicultural method may be applied, while if the same type is managed with the aim of converting it into white pine or spruce stand, another method is necessary. The best silvicultural practice cannot be brought about by legislation which would attempt to prescribe definitely how different forests should be cut. No forester who is careful of his professional reputation would attempt at this time to outline a definite silvicultural practice for the different forests and forest conditions. All that can be attempted here, then, is to outline a few principles which would be desirable to recognize either as a basis for a broad legislative measure or as a general public requirement that may be laid down by State or Federal forest authority.

1. More effective forest fire protection.

Although in outlining minimum public requirements adequate fire protection is considered the one irreducible minimum, yet most effective fire protection cannot be attained except in conjunction with silvicultural practice. Adequate fire protection will be secured, not by developing an efficient fire protective organization only, but also by making the forest itself fireproof.

Fire protection should be not merely a medicine, a drug, but a prophylactic, and this can be attained only by better handling of the forest itself. To secure adequate fire protection it is desirable, as has already been pointed out, to classify the forest land in the State on the basis of permanent forest land and temporary forest land, and provide thorough fire protection to the permanent forest land even at the cost as high as 10 and 15 cents per acre.

2. Elimination as far as possible of clear cuttings, at least over large contiguous areas.

This is a principle which underlies most of our cuttings on National Forests. As a general principle it will assure a continuation of the present character of the forest. It will provide for the large-sized trees in a nearer future than if the forest is cut clean. It will tend to bridge over the gap between the exhaustion of the old timber and the maturing of the second growth. It may not be the best silvicultural practice in all cases and under intensive forest management, when quicker returns may be secured by clear cuttings and planting or some other silvicultural method. It is, however, a safe desirable forest practice to adopt for general guidance and it is very well suited for most of the forest types found in the Northeast.

In the swamp type of forest partial cutting is a desirable practice from a silvicultural standpoint and is practical because of the character and composition of the mixed swamp stand. Partial cutting is also feasible, with certain precautions, in the spruce forests, particularly on protected slopes; at high altitudes and on exposed slopes very light partial cuttings may be necessary, or cuttings in narrow alternate strips. Partial cutting is also adapted to white pine stands. This is particularly true in the case of white pine on hardwood land. Selection cutting seems to be particularly suited for the northern hardwoods, such as maple, birch, and beech, which as a rule have an admixture of hemlock and spruce. The same is true of the southern yellow pine forests such as pitch, shortleaf, and scrub pine, found in New Jersey and some parts of Pennsylvania.

In the case of the southern hardwoods or so-called sprout hardwoods, the desirable silvicultural practice must aim (1) to aid in securing reproduction of the more valuable hardwoods after the land has been cut over for the dead and dying chestnut or other mature timber, and (2) to convert the cut-over hardwood land into white pine stands.

The waste land, or land covered with scrubby growth that has no promise of developing into a forest of economic importance, should be planted with species suitable for the site.

With elimination of clear cuttings, the fire menace in itself will decrease. This, together with a thorough fire protection for the permanent forest land, will make the forest safe against devastating fires.

3. Burning of coniferous slash is a desirable practice and should be made universal.

4. Lopping and scattering of hardwood slash, except aspen and white birch slashing, is also desirable.

5. Creation of special protection forests, which are to receive special fire protection from the State, for which the timber owners would be willing to submit to certain restrictions in the method of cutting.

6. Prevention, as a general rule, of depletion of existing forests by the owners, clearly defining what constitutes depletion, but leaving to the owner the choice of method by which to attain this, or by allowing cutting of large areas only according to such methods as may be approved by a State or Federal forest authority.

7. Control of the white pine blister rust, spruce budworm, and gypsy and brown-tail moth.

<u>Digest of Public Requirements Report for the Southern Coastal Plain Region</u>

R. D. Forbes

1. Turpentining or cutting.

a. Reserve seed trees at rate of 4 longleaf per acre, or two of other species. (Advance reproduction often lacking, no stored seed; pines wind-firm, light seeded.) Seed trees over 9", vigorous. Increase number of reserved trees if small or unavoidably bled.

and b. Turpentine unreserved trees conservatively. (Otherwise there is danger of severe insect and fire loss among seed trees.)

or c. Reforest artificially. Requires 400 longleaf or 650 seedlings of other pines, well spaced, at 10 years after cutting.

and 2. Slash disposal.

a. Remove slash 20' from seed trees. Requirement waived if number of seed trees is twice that prescribed, but seed trees must be over 9" and unbled.

and b. Employ one of following alternatives:

either (1) Intensive fire protection for five years. Requires fire lines around each forty, and fire protective force to reach fire within one hour of occurrence.

or (2) Careful broadcast burning first fall or winter following logging. (Alternative only when effective five-year protection cannot be hoped for; sacrifices advance reproduction.)

and 3. Fire protection after turpentining or logging.

a. Assume usual laws against firing private property, and general organization for public education and extensive protection.

and b. Rake around all seed trees or those in uncut turpentined stands for five years.

and c. Give intensive protection at all fire seasons for 10 years to new crop following good seed fall. Requires fire protective force to reach fire within two hours of occurrence.

and d. Give same protection during droughts in vegetative season throughout life of stand.

and e. Equip logging machinery and locomotives with spark arresters, and construct fire lines along railroads.

and 4. Protection against hogs

a. Exclude hogs for ten years from longleaf reproduction near farms and settlements.

B. Bottomland Hardwood Type

1. Cutting

a. Reserve seed trees at rate of 2 per acre. (No departure from present sawtimber logging, but to prevent devastation in pulpwood or cordwood operations.) Seed trees over 10", vigorous, of prescribed species (see list).

and 2. Slash disposal

a. Employ one of following alternatives. Requirement waived if number of seed trees is twice that prescribed.

Either (1) Intensive fire protection for three years. Requires protective force to reach fire within one hour of occurrence.

Or (2) Removal of slash 20' from seed trees.

and 3. Fire protection

a. Assume usual laws against firing private property, and general organization for public education and extensive protection.

b. Give intensive protection at all fire seasons to virgin stands and second-growth up to 25 years. (Advance growth general, fairly easy to conserve.) Requires protective force to reach fire within two hours of occurrence.

c. Equip logging machinery and locomotives with spark arresters, and construct fire lines along railroads.

C. Upland Hardwood Type

1. Cutting. As for bottomland hardwoods, except for species of seed trees (see list).

and 2. Slash disposal. As for bottomland hardwoods, except that intensive protection is for 3 to 5 years.

and 3. Fire protection. As for bottomland hardwoods.

and 4. Protection from grazing.

a. Reduce as far as possible number of stock for 10 years after cutting.

D. Cypress and Tupelo Type

1. Cutting

a. Reserve seed trees at rate of 3 per acre. (No departure from present sawtimber logging, but to prevent devastation in pulpwood or cordwood operations.) Seed trees over 12", cypress or gum. Hollow cypress permissible.

and 2. Other measures.

a. Assume usual laws against firing private property, and general organization for public education and extensive protection.

E. Juniper Type

1. Slash disposal. Adopt one of following alternatives:

Either a. Burn slash the first winter after logging when swamp is full of water.

Or b. If burning is impossible without damage the first winter, give intensive protection at all fire seasons for 10 years after logging. Requires protective force to reach fire within one hour of occurrence.

2. Fire protection

a. Assume usual laws against firing private property and general organization for public education and extensive protection.

b. Equip logging machinery and locomotives with spark arresters and construct fire lines along railroads.

Digest of Desirable Forestry Practice Report for
the Southern Coastal Plain Region
R. D. Forbes

The public requirements outlined for every type are a part of desirable forestry practice, with the following modifications:

A. Pine Type

1. Turpentining or cutting

a. The number of seed trees left will be based on their size and seed-bearing capacity. Their distribution will be based on the requirements of each individual acre. (None at all might be necessary on an acre already well stocked with advance growth beyond injury by ordinary fires.)

and b. Where warranted by economic conditions, thrifty trees below a rough diameter limit will be left for growth and as the basis for a second or third turpentining or cutting cycle.

and 2. Slash disposal

a. All standing trees and promising advance reproduction will be safeguarded by some form of slash disposal.

and 3. Fire Protection

a. Fires will be kept out of stands throughout their entire life

and b. Firebreaks will be established at intervals in cut-over areas.

and 4. Artificial reforestation.

a. Blanks remaining from natural reforestation after ten years will be sowed or planted.

B. Hardwood Types

1. Cutting

a. As under "Turpening or cutting" in Pine Type.

and b. Where it can be done cheaply, seed trees of unmerchantable or inferior species, and wolf trees of good species when not needed for seed, will be felled or deadened.

and c. Where practicable (as in a farm woodlot) to vary time of cutting to encourage sprouting of good species, or to discourage sprouting of poor species, it will be done.

and 2. Fire protection.

a. Fires will be kept out of stands throughout their entire life.

and 3. Artificial reforestation.

a. Blanks remaining from natural reforestation after five years will be sowed or planted.

C. Cypress and Tupelo Type

1. Cutting.

a. The number of seed trees left will be based on the requirements of each individual acre.

and b. Cypress seed trees will be left.

D. Juniper Type.

Leave 2 seed trees of slash pine when it occurs in mixture. This also applies to pond pine in North Carolina.

## Digest of Report on Devastated Lands for the Southern Coastal Plain Region

R. D. Forbes

### Pine Type

Probably 25 out of the 35 million acres of land now devastated may be restored to productivity through intensive fire protection and protection from grazing, as described in the "Public Requirements on Forest Lands." The remaining 10 million acres will have to be planted; the process is simple, fairly sure, and the per acre cost low.

### Hardwood Types

The small areas devastated (chiefly by grazing in farm woodlands) can be restored to producitivity by protection against fire and grazing.

### Cypress and Tupelo Type

Devastation is probably unimportant and due to lack of seed. Planting would be difficult and costly.

### Juniper Type

"Juniper lights," or devastated areas produced by fires which destroyed both seed trees and seed stored in the soil, are of important extent. The only remedy is planting, a difficult job on such a site, and one of which we know nothing.

## Digest of Public Requirements Report for the Lake States

Raphael Zon

1. Five commercial forest types are recognized in the Lake States:

1. Northern hardwoods of birch, beech, maple, pure or with admixture of hemlock.

2. Aspen and white birch.

3. Norway and white pine.

4. Jack pine.

5. Swamp forests.

2. Provided fire protection is given to the cut-over areas, there is no need of restrictions in the method of cutting in any of the five commercial types.

3. Special fire protection measures are necessary at the time of logging. These are: clearing of the rights of way along logging roads, highways, trails; clearing safety strips around green timber, settlers' home, and sawmills. Other precautionary measures, such as spark arresters on all engines and burning oil on all locomotives through particularly dangerous districts at certain times of the year, assignments at lumber camps of certain persons to act as leaders in organizing fire crews and similar measures now well recognized and more or less enforced in most of the Northeastern States.

4. Brush disposal from a silvicultural and fire protection standpoint is desirable particularly in Norway and white pine forest.

5. There should be a general brush disposal law authorizing the State Forester to prescribe methods of brush disposal, as well as the authority to enforce the clearing up of certain dangerous areas either by actual removal of the inflammable material or the clearing of safety strips.

6. General fire protective organization in the States which would provide for a permanent force for directing fire protection work in the State. Each county or more counties to be in charge of efficient permanent forest officers. These are to direct the work within the districts and act as inspectors with administrative power over the lookout and patrol force.

7. An adequate lookout and patrol force which could detect forest fires before they exceed one-tenth of an acre in size or within 15 or 20 minutes after the fire starts.

8. The organization of a suppression force that could reach the fire after it is located before the fire exceeded one acre. No fires on an average should be allowed to exceed 10 acres in area, or in general should be allowed to run over one night. In general, an organization that could reduce the area burned over annually to from one-tenth to one-half of one per cent of the total forest area. The cost of fire protection it is estimated will be about 5 cents per acre.

9. Classification of the forest in the State on the basis of fire hazard. Clear recognition of the need of a different method of fire protection for lands presenting a different fire hazard.

10. Organization of the State-owned forest lands into State forests. The permanent personnel on these forests, while engaged in the upbuilding of the State forests should, at the same time, constitute the fire protective organization and act as a nucleus for an efficient fire protective system outside of the State forest.

Digest of Desirable Forestry Practice Report for the Lake States
Raphael Zon

The minimum public requirements will prevent forest land after cutting becoming totally unproductive. They will not, however, secure the highest possible productivity of the land. The minimum public requirements will not balance the present discrepancy between depletion and growth. In order to bring the growth of our forests to the point where it can meet our present needs, forest practice must be developed which will go beyond the minimum public requirements.

What this silvicultural practice should be for the different forest types and forest conditions is a very difficult thing to formulate. Under intensive forest management a forester may use different silvicultural methods and yet attain the same result. There is no universal silvicultural method even for the same type which will produce the best results. The silvicultural practice must vary not only with the forest type but also with the purpose which the timber owner may have in growing this timber. If, for instance, an aspen stand is to be managed for the production of aspen pulpwood one silvicultural method may be applied, while if the same type is managed with the aim of converting it into white pine or spruce stand, another method is necessary. The best silvicultural practice cannot be brought about by legislation which would attempt to prescribe definitely how different forests should be cut. No forester who is careful of his professional reputation would attempt at this time to outline a definite silvicultural practice for the different forests and forest conditions. All that can be attempted here, then, is to outline a few principles which would be desirable to recognize either in a legislative measure or as a general public requirement:

1. More effective forest fire protection.

Although in outlining minimum public requirements adequate fire protection is considered the one irreducible minimum, yet most effective fire protection cannot be attained except in conjunction with other silvicultural practice. Adequate fire protection will be secured, not by developing an efficient fire protective organization only, but also by making the forest itself fireproof.

Fire protection should be not merely a medicine but a prophylactic, and this can be attained only by better handling of the forest itself. To secure adequate fire protection it is desirable, as has already been pointed out, to classify the forest land in the State on the basis of permanent forest land and temporary forest land, and provide thorough fire protection to the permanent forest land even at the cost as high as 10 and 15 cents per acre.

2. Elimination as far as possible of clear cuttings, at least of large contiguous areas.

This is a principle which underlies most of our cuttings of National Forests. As a general principle it will assure a continuation of the present character of the forest. It will provide for the large sized trees in a nearer future than if the forest is cut clean. It will tend to bridge over the gap between the exhaustion of the old timber and the maturing of the second growth. It may not be the best silvicultural practice in all cases, since under intensive forest management often quicker returns may be secured by clear cuttings and planting or some other silvicultural methods. It is, however, the desirable forest practice as a general thing and is very well suited for most of the forest types found in the Lake States.

Partial cutting, as it is now practiced on the Minnesota and other National Forests, is undoubtedly the most desirable practice for the old stands of Norway and white pine. Partial cutting is particularly suited for the northern hardwoods, such as maple, beech and birch, which, as a rule, have an admixture of hemlock. As a matter of fact, it is only through partial cutting that the hemlock may be saved in second growth. In the swamp forest partial cutting is the desirable practice from a silvicultural standpoint and is the most practical because of the character and composition of the mixed swamp stand. The peculiar type found in the Superior Forest on the outcrop formation of mixed old white pine with cedar, balsam, jack pine, aspen, and white birch, needs particularly careful selective cutting. In the case of pure jack pine and aspen stands partial cutting, if the aim is to perpetuate the two species, is not essential. In the case of jack pine, however, partial cutting is entirely feasible, although it has no particular advantage over clear cutting if the area is protected from fire after it has been restocked. There are, however, many jack pine stands into which the Norway pine begins to creep back. Thinnings in the jack pine stands should become an essential part of more intensive handling of this type. They may be considered as partial cutting since the product of the thinnings is already merchantable. Under such conditions cutting of jack pine and favoring of Norway pine is certainly a desirable practice. The same is true of aspen stands which have an understory of white pine or spruce. In such case the release of the coniferous species from the shade of the aspen and its conversion into a coniferous stand becomes a desirable practice.

With elimination of clear cuttings, the fire menace in itself will decrease. This, together with a thorough fire protection for the permanent forest land, can be made safe against devastating fires.

3. Burning of coniferous slash as well as of hardwood slash at the time of logging in winter or in the midsummer would be an advance in the handling of the forests.

4. Prevention of depletion of existing forests by the owners, leaving to the owner the choice of method by which to attain this, or by allowing cutting of large areas only according to such methods as may be approved by a State or Federal forest authority.

5. Control of spruce budworm, larch and jack pine sawfly.

Digest of Report on Devastated Lands for the Lake States
Raphael Zon

The policy toward denuded forest land may be briefly stated as follows:

1. A careful survey of the nonrestocking area with the view of determining its condition and present and potential value.

2. A complete fire protection of denuded forest land.

3. The State should first attempt to reforest its own denuded land in need of artificial reforestation.

4. The State should select land which needs to be reforested first. It should be selected with the idea of forming large forest bodies capable of sustaining permanently, either by themselves or in conjunction with other second growth in the vicinity, wood-using industries.

5. The State should encourage, wherever necessary, planting by private timber owners through distribution of planting stock at cost, provide advice as to species, methods, and care of the plantations.

6. The State should work out a system of forest taxation suitable for encouraging growing timber.

7. Under certain circumstances the State may even lease land from private owners in case the latter are unable to do so themselves, and reforest it. The owner is to retain the right to redeem the land, together with the timber on it, by paying the cost of reforestation and other charges.

Digest of Public Requirements Report for the Appalachian Hardwoods
E. H. Frothingham

Region

The Piedmont Plateau, the Appalachian Mountains, the Appalachian Valley, and the Cumberland and Allegheny Highlands

Type Groups

1. Spruce forest. 2. Moist site hardwood forest. 3. Dry site forest. 4. River edge forest.

General Requirements

Protection

1. Adequate fire protection decreases the emphasis to be placed upon silvicultural measures.

2. A competent State fire protection organization or its equivalent, to enforce fire laws and carry on educational work. To include

A head warden for each 150,000 acres of woodland.
A warden for each 10,000 acres of woodland.
A lookout system.

3. Legal control of burning by a permit system.

4. Legal provision for the placing of responsibility on the creator of special hazards. Railroads, sawmill operators, and persons setting fires for the clearing of land.

5. Control of public carelessness with fire.

6. Cost of $.02 per acre a public charge, cost of extinction to be charged against the agency responsible for the fire.

7. Grazing. While grazing will result in deterioration of some of the most valuable cove stands, the present practice will not bring about devastation of appreciable areas. The most serious injury is in fenced pastures, where enforcement is most difficult because of the number of cattle involved. Since the attempt to establish a restriction for a period of years would work out with extreme difficulty or injustice, the grazing restrictions are withdrawn.

Silvicultural

Adequate regeneration to secure a stand as valuable as that removed. Definition of seed trees.

1. Seed trees of white pine, yellow poplar, and shortleaf pine on sites where they occur, at the rate of one tree for each three acres, well distributed.

2. Brush and tops not closer than 10 feet from seed trees (20 feet in pure pine stands - plateau type).

The difference between mountain and plateau forest of corresponding name is principally from the standpoint of requirements, a matter of size of tracts under individual ownership, density of population, accessibility, and protective separation by roads and fields.

1. Spruce Forest. High mountain peaks and ridges above altitudes of from 3,500 feet in West Virginia to 4,500 feet at the southern extremity of the range.

On upper slopes and crests balsam occurs in mixture and sometimes predominates; advance growth plentiful, largely balsam where this occurs in the main stand. Middle slopes commonly a pure stand of spruce, more deficient in the smaller sizes, advance growth and reproduction, than the upper slopes. On the lower slopes, spruce is mixed with other "northern" species, particularly hemlock and yellow birch. Here the hardwoods when established outgrow the spruce.

Forest floor naturally fire resistant. Heavy slash left by present methods of logging present extreme fire hazard lasting 10 to 20 years. Abundant seed production only at intervals of five or more years for spruce and three or more years for balsam. Little probability of complete or immediate replacement, except through ample advance growth, secured before the stand is completely removed.

Present logging practice

Railroad logging with overhead skidding, ground skidding, and animals. Heavy outlay makes complete utilization necessary. Heavy cutting precludes adequate spruce regeneration. The remote situation makes railroad logging the best method of getting out sawtimber. Steam logging a prevalent source of fire.

Requirements (Protection)

Owners shall so protect cut-over land that at least 80 per cent will be free from devastation by fire at the conclusion of the cutting. No contiguous area of more than 200 acres of such burn. Otherwise plant such burned areas with at least 250 suitable trees per acre.

Patrol by operators at rate of 1 man for each 3,000 acres of slash less than 10 years old.

Prevention measures suggested.

Requirements (Silvicultural)

If a system of partial cutting is not used, a limit of cutting to 5" DBH is imposed for spruce and fir. Care to be used in logging to prevent injury of these trees.

2. Moist site hardwood forest

Includes all hardwood forest on moist sites below the spruce in the mountains and plateau, except the strip along stream banks.

(a) Upper moist slope type - northern hardwood, hemlock, white pine.

(b) Lower moist slope type - mixtures of red oak, chestnut, ash, linn, buckeye, cucumber, black cherry, other oaks, hickories, poplar, etc.

(c) Cove - Complex mixtures of hardwood, sometimes pure hemlock.

Reproduction is satisfactory to prevent devastation, if protected from fire, with general silvicultural requirements. The chief impediment to future production is cull trees left in the woods. The best reproduction of partially tolerant trees on the lower slopes and most severe fire injury in the upper types.

Present logging practice

RR logging with steam skidding and animal logging (variations). Comparatively clear cutting in the coves, large number of cull trees left in the upper types. Some fluming and gravity slides for wood. Portable mills and wagon haul of lumber. No restriction as to logging methods.

Protection requirements

Protective devices for steam engines, with clearing of rights of way and around skidder sets.

Operator to furnish labor for the control of fires, also tools. Patrol of slash less than 5 years old for 4 years in the lower moist slopes and coves, and 5 years in the higher types. No special silvicultural requirements.

3. Dry site forest. Includes ridge and dry site type within the mountains and pine, hardwood or mixed stands on ridges and slopes of dry exposure. Characteristic species are chestnut, chestnut oak, scarlet oak, pitch pine and locust. Other species of oak and hard pine, hickory, black gum and red maple found here. White pine may extend into this type. Stand is generally scattered and defective with a large percentage of the area too poor to pay the cost of logging.

The Plateau type. Either hardwood, pine or mixed stands on low ridges and hills skirting the mountains and comprising part of the woodland of the Piedmont Plateau and Appalachian Valley. This forest has been much damaged by fire in the mountain section and now has a large percentage of trees of sprout origin. Repeated fires have favored hard pines on the exposed ridges and have increased the amount of laurel in the undergrowth. In the smaller fenced woodlands, grazing has decreased the amount of hardwood and favored pine stands.

Chiefly animal logging, cutting ties; acidwood and fuel. Some portable mill operations. In the mountains the practice of taking only the best trees of the desirable species tends to cull the stand and leave a stand poor in quality to occupy the land. No cutting restrictions except seed tree provision.

Fire protection

Same measures as in the moist site except that patrol may be replaced by observer system. In pine stands closely approximating the conditions of the coastal plain, protection requirements similar to those of the Coastal Plain.

Silvicultural requirements

Two seed trees per acre of light seeded valuable species or three of heavy seeded hardwoods. Planting requirement in case of clear cutting similar to that of coastal plain where conditions are similar.

4. River Edge Forest

Narrow strip along the main streams. Not important in area.

## Public Requirements Conference

X-1. Digest of Public Requirements for the Southeastern Mountain and Highland Region south of Pennsylvania.

E. H. Frothingham

### Region

The Piedmont Plateau, the Appalachian Mountains, the Appalachian Valley, and the Cumberland and Alleghany Highlands

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Prevention measures suggested.

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Chiefly animal logging, cutting ties, acidwood and fuel. Some portable mill operations. In the mountains the practice of taking only the best trees of the desirable species tends to cull the stand and leave a stand poor in quality to occupy the land. No cutting restrictions except seed tree provision.

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Same measures as in the moist site except that patrol may be replaced by observer system. In pine stands closely approximating the conditions of the coastal plain, protection requirements similar to those of the Coastal Plain.

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Two seed trees per acre of light seeded valuable species or three of heavy seeded hardwoods. Planting requirement in case of clear cutting similar to that of coastal plain where conditions are similar.

4. River Edge Forest

Narrow strip along the main streams. Not important in area.

Digest of Desirable Forestry Practice Report for the Appalachian Hardwoods

E. H. Frothingham

## Region

The Piedmont Plateau, Southern Appalachian Mountains, Appalachian valleys, and Cumberland and Alleghany Highlands.

## Management of Forest Tracts

The silvicultural practice recommended involves subsequent as well as immediate treatment and seems to require an introductory statement of a few essentials of management. This statement includes business principles of administration and a simple explanation of regulation. For the region as a whole, reasons are given for anticipating a rough natural regulation of the cut.

## General Forest Protective Measures

The general public requirements for forest protection constitute desirable practice except as modified or extended in special cases described in the desirable practice report.

## General Silvicultural Measures

Large number of species and topographic and climatic conditions result in a wide variety of forest conditions. This is further complicated by successive cullings and fires, tending to decrease the proportion of desirable species. Each case must be considered on its merits according to general principles here outlined. Logging must be modified as necessary and close utilization practiced. Machine logging cannot be practiced without undue injury where trees are to be held for future growth.

## Type Groups

Same as in the public requirements report. Some exceptions and finer distinctions will be made without further subdividing the "types" there recognized.

1. Spruce forest

Desirable protective practice. This type presents greatest menace and is subject to greatest injury of all the forest types. Best protection is by light cutting to reduce fire hazard from slash, supplemented by special measures suggested in public requirements report wherever a special menace is involved. These include patrol at the rate of one man for each 3,000 acres (or less) of slash less than 10 years old, the use of improved cabbagehead stacks, with screens, and ashpan sprays for locomotives, and extreme care in dumping ashes and in handling fire in any way. In addition, spruce slash within 100 feet of railways should be burned or removed.

Desirable silvicultural practice for old-growth spruce and fir stands: Selection cutting, removing the largest trees and leaving about three-fourths of the overhead shade. Departure from this principle indicated for special cases. Light second-cut in 25 years will release crowns of smaller trees and admit light to reproduction. Third cut 25 years later will leave a young, actively producing forest for sawtimber (100-year rotation, 4 cutting cycles) or pulpwood (50-year rotation, 2 cutting cycles). Pulpwood rotation (50 years) and operation by flume, where water is available, are advocated.

For mixed spruce and hardwoods or hemlock: Where hardwoods are few they should be removed at first cutting except where serious danger of windfall of adjacent spruce, fir, or hemlock would result; otherwise proceed as for pure old-growth spruce type. Where hardwoods (commonly yellow birch) are abundant, best to cut lightly, admitting enough light for spruce, fir, or hemlock, but not enough for good development of less tolerant hardwoods. By repeating procedure softwood reproduction may be established.

These recommendations exceed public requirements by providing safer and surer silvicultural methods and reduction of fire hazard; and by extension through several cutting cycles.

2. Moist slope hardwoods

Desirable protective practice. This should correspond with the practice called for under public requirements. Grazing should be excluded from reproducing hardwood stands for 5 or 10 years, or until the majority of the trees have grown out of danger.

Desirable silvicultural practice. Clear cutting, reservation of seed trees where advance growth of desirable species is inadequate or lacking, and subsequent culture of second growth are recommended. Removing most of the crown shade will favor growth of light-needing species. The chief hindrance to good second growth has been the indiscriminate leaving of poor holdovers. These should be cut or girdled; but thrifty groups of second-growth trees, too small to have much present value, should be left intact. Early liberation cuttings on reproducing areas and thinnings to improve composition are advocated where practicable. Seed trees should be trees of desirable species, at least 10 inches d.b.h., with well developed, thrifty crowns.

For upper slope hardwoods, the first thinning will probably take place in 25-30 years, and the second 10 or 15 years later. Management will probably be for a combination of sawtimber and distillate or other small-sized stock. Rotation period for sawtimber is 60 to 80 years or longer, depending upon species and site. Number of seed trees left open.

For lower slope and cove hardwoods, thinnings should be begun at earliest date at which they will pay for themselves and thereafter at intervals as required. Sawtimber rotations of from 50 to 70 years are indicated, but shorter rotations for pulpwood may be practicable. Seedling reproduction is to be preferred to that from sprouts. For cutting of present stands, seed trees to be left at rate of one seed tree of light-seeded species (more for heavy-seeded species) for each two acres.

For farm woodlands the group selection method of management is recommended.

Desirable practice for moist site hardwoods exceeds requirements in following respects:

1. Number of seed trees: left to judgment in case of upper slope hardwoods; increased to one tree for two acres of light-seeded species, more of heavy-seeded species.

2. Species of seed trees; includes other desirable species in addition to white pine and yellow poplar.

3. Reserve groups: groups of small thrifty timber to be left intact.

4. Inferior species and defective trees: to be removed wholly or in part.

5. Subsequent culture: includes provisions for later treatment of second growth and ideas as to future management.

6. Group selection method: recommended for farm woodlands.

3. Dry site forest

Products principally railroad ties, low-grade lumber, and tanning extract stock. Logging value low due to relatively difficult access (in the mountains), low yields, and poor quality of sawlogs. Forest growth value low for same reasons and because of slow growth, long reproductive period, and bad fire hazard. Most of this land has already been badly burned.

Desirable protective practice. Same as outlined for public requirements. Fire menace great, even on small isolated woodlands, necessitating more care to apply other measures outlined as requirements. In logging pine stands on the Piedmont Plateau, resembling Coastal Plain conditions, the special protective measures called for in public requirements and desirable practice for the Coastal Plain should be regarded. To minimize danger of loss from insect attacks, pine should be cut in late fall and early winter. Attacked trees should be disposed of

in accordance with recommendations by the Bureau of Entomology. Livestock should be excluded from cut-over areas until reproduction is beyond danger of injury, except that light grazing may be relatively harmless to ample and well distributed pine reproduction. Where reproduction is sparse, stock should be excluded for two years previous to cutting so that seedlings may become established.

Desirable silvicultural practice. For dry slopes and ridges which have been cut over and badly burned, no treatment suggested other than fire protection to permit gradual recovery; but best production can be secured by planting with conifers adapted to the site.

For old stands, where conditions justify logging, the public requirements, which make no restriction as to cutting except the leaving of seed trees, may be bettered by partial cutting, reducing crown cover to 50 per cent, removing gum, red maple, sassafras, and the more defective trees, and favoring pines, locust, and oaks (except scrub, black jack, and usually post oaks). The remainder of the old stand should be removed as soon as the reproduction is in good enough condition, probably within 10 or 20 years if protected.

Where good second growth already occupies half or three-quarters of the surface, scattered holdovers should be removed at once. The second growth should be thinned when this can be done profitably. Intermediate yields can probably be obtained from 30-year old stands. Thinnings should favor better species. Rotation of greatest volume production in mountain hardwoods is 50-70 years for cubic feet and 100-130 years for lumber, but lumber will rarely be an object. For farm woodlands, especially hardwoods, the group selection method of management is recommended.

4. Lowland and river edge forest

This forest is relatively unimportant in area. It may be handled in practically the same way as the lower moist site hardwood forest.

## Digest of Report on Devastated Lands for the Appalachian Hardwoods

E. H. Frothingham

1. Spruce type

From a quarter to a half of the spruce type cut-over lands may properly be described as devastated. These are old clear cuttings which have been burned one or more times at altitudes and on soils which will not support a growth of hardwoods of commercial value. These will not come back into production through protection alone within a period much longer than 20 years.

Treatment recommended: Planting of burned areas as soon as possible after the burn with red or Norway spruce or other tolerant hardy conifers which have proved satisfactory. Plantings should be inspected every few years and liberation cuttings made where needed.

2. Moist site hardwoods

Logged and repeatedly burned and heavily grazed lands in the upper moist site hardwoods, in which brushy cover of laurel, rhododendron and other shrubs and shrublike trees have become densely established. There is very little of this which will not restock naturally with at least the more tolerant tree species within a period of 20 years if protected.

In lower moist site hardwoods the only devastation is that on cleared and cultivated slope land which has been abandoned and is eroding. Such small scattered openings will usually restock naturally if protected for a period of 20 years. Accessibility and quality of such lands will probably justify planting.

3. Dry site hardwoods

Production in these types is slow and poor at best. They are more inflammable and the site, through exposure, is more subject to deterioration than in the case of the moist site types. Continued fires favor heavy growth of laurel, huckleberry, greenbrier, etc. Detached areas, large in the aggregate, have run down practically to the point of devastation as defined for this report. If protected from fire these will as a rule become restocked with commercial species within 20 years. When sufficiently accessible to make it an object, planting with conifers adapted to the site will increase the productivity of these lands. Planting should be done immediately after burns to minimize competition.

## Digest of Public Requirements Report for the Central Hardwood Region

C. R. Tillotson

### Measures Necessary to Insure Timber Growth

The Small Farm Woods: The small isolated farm woods are largely culled and fully 75 per cent heavily grazed. The fire hazard in these woods is practically negligible. To be sure, occasional small fires occur, but these cannot spread far and do little damage in the aggregate. Public sentiment is against them and there is no need of any special organization to combat them. Aside from clearing operations by the farmers, the one thing that is preventing the continuation of forest growth in these small isolated farm woods is the practice of grazing them heavily.

Nearly all hardwoods are subject to browsing by stock. Elm, ash, maple, basswood, and tulip poplar appear especially subject to grazing; hickory, the oaks, cottonwood and red gum are less relished. Stock can be starved into eating almost any kind of hardwood reproduction. The damage is worse in the spring of the year when the growth is tender and grass has barely started and during hot dry summer spells when the grass is dried up. Hogs are partial to the acorns of the white oaks, but in the absence of these devour those of the red oaks. Where hogs run in the woods the chances for white oak seedling reproduction are considerably lessened. Since small farm woods are in the ownership of a great many people, and since they make up the bigger part of the area in woods in the central hardwood region, livestock should as a desirable measure be excluded from woods in which the trees have not reached a diameter of 4 inches or better. This will ordinarily require a period of 20 to 25 years. After that time livestock could be allowed in the woods until the stand began to thin out naturally or the trees were cut to such an extent as to leave openings which would seed in naturally if stock were excluded. This, however, is a desirable requirement rather than one which it seems possible to put into effect through legislation. It seems utterly impractical to control grazing in small farm woodlots. Too little is known of the value of the forage and shade to indicate even whether it is a desirable economic practice to exclude livestock. Public requirements are not proposed, accordingly, for such woodlots. The State foresters themselves are opposed to the idea of attempting legislation to regulate grazing or cutting in farm woods, although recognizing for the sake of timber production the desirability in particular of grazing restrictions.

<u>The Large Contiguous Areas of Woods</u>: The contiguous or nearly contiguous areas of timberland in the region, making up a total, perhaps, of from 15 to 20 million acres, represents a poor soil type to a large extent, and a poor type of farm country. The timber runs very largely to oaks and hickory, with some yellow poplar, beech, maple, ash, chestnut, shortleaf pine, red cedar, and other species. The region is characterized by lack of fences and a very poor and for the most part illiterate class of people. Livestock runs at large but is not present in sufficient numbers to cause material widespread damage to timber in itself. Indirectly it is the cause of a big proportion of forest fires which are set out by livestock owners to clear out the undergrowth and improve grazing conditions. Forest fires are more or less common in this region, but even so, have not brought about devastation. They kill the young growth back to the ground and fire-scar severely with resultant subsequent deterioration that which has reached a size too large to be killed back by an ordinary fire. Past cuttings, clear and partial, indicate conclusively that reproduction, either of seedlings or sprout origin, will follow cutting operations. The species in the reproduction will be the same as in the stand cut over, although the proportion of each may differ materially. The matter of securing reproduction and of insuring a final stand of mature timber in a good healthy condition is purely one of fire prevention. Absolute fire prevention for 20 years after cutting is a requirement which should be sought for this region. In effect, protection for 20 years secured through deliberate measures

ought to be easily translated into protection for all time. The term "absolute" is used in the full knowledge that it will be impossible to attain. Nevertheless, it is the goal which should be set for achievement. Approach to its consummation will come in part through some of the following measures:

1. Adequately financed State fire protective organizations embodying the features of prevention, detection, and prompt suppression.

2. Laws designed to curb the careless or malicious setting of fire to woods.

3. Laws requiring the fencing in of livestock.

4. Laws requiring a permit to burn brush during certain seasons of the year.

5. Laws giving the State Forester broad authority to enforce disposal of brush or other inflammable material where it is a special hazard and high risk to forest land.

6. Laws enforcing the use of spark arresters and ash pans of an approved type on all coal and wood-burning locomotives and stationary engines operating in or near forest lands during the dangerous fire season, and the annual clearing previous to the fire season of a 100 to 150-foot strip of land along the railroads of all inflammable material.

7. Laws enforcing timber operators to provide special protection to areas during logging operations and where they have created a special hazard as determined by the State Forester so long as logging operations continue and the special hazard exists.

## Digest of Desirable Forestry Practice Reports for the Central Hardwood Region

C. R. Tillotson

### Object

The object of "desirable forestry practice" as indicated in the outline should be to produce the maximum amounts of timber of the species "which can be grown to the best economic advantage on the site." In producing timber for the market, this will ordinarily mean species which occur naturally in a region because the local markets for timber have been built up around them; in producing it for the owner's own use, other species may be introduced if they are more suitable for the purpose in view.

### Types

For the purpose of discussing "desirable practice" in the region it seems essential to distinguish only the three following general types:

(1) Upland hardwoods
(2) Bottomland "
(3) Mixed stands of pine and hardwoods

Factors influencing Desirable Practice

(1) Selection of best trees and best species in past cutting has left a stand of poor grade.

(2) Pasturing has reduced the vigor of stands and caused them to become open.

(3) Fire has greatly reduced the value of the stand where it has occurred.

Damage greatest in fenced woodlots. The great number of owners involved and need for shade for stock will make possible the saving of only a part of the hardwood woodlots from stock injury.

Removal of stock is recommended on unfenced lands because it induces burning. In mixed stands of pine and hardwoods, elimination of grazing is not so essential.

Methods of Cutting

Summing up then the methods of cutting proposed in so far as economic factors will permit are:

(1) For upland hardwoods: cut valuable species to a diameter of 16 or 18 inches; cut species of little value to lowest merchantable diameter; cut weed trees out entirely.

(2) For bottomland hardwoods: cut valuable species to a diameter of 30 inches; cut species of little value to lowest merchantable diameter; cut weed trees out entirely. If high diameter cutting limit cannot be maintained for valuable species, cut the stand clean of all stems.

(3) For mixed stands of pine and hardwoods. On south slopes and ridges cut pine to a 12 or 14-inch diameter limit taking not over 50 per cent or 60 per cent of stand. Cut all hardwoods. On north slopes cut hardwoods the same as other upland hardwoods and pine to a 12 or 14-inch diameter limit. Where pine occurs in nearly pure stands, cut to a 14 or 16-inch diameter limit with the restriction however, of cutting not over 50 per cent or 60 per cent of the stand by volume.

(4) Badly culled, burned, and grazed stands must first be rejuvenated by excluding grazing and fires. With reproduction established, cut out old decadent and broken trees as well as formerly suppressed spreading trees left after logging. Thereafter handle like other stands.

(5) Even-aged young pole stands in regions where there is a demand for mine props must be handled in accordance with a flexible diameter limit system of cutting. This limit will vary with the current demand for props of various sizes.

## Summary of Devastated Land Problem in the Central Hardwood Region

C. R. Tillotson

In the central hardwood region there are perhaps two million acres of land confined to ridge tops and high plateaus that are bearing a scrubby growth of black jack oak, post oak, and scattering white and black oak. The greater proportion of this land occurs in the Ozark region. The blackjack timber is practically worthless except for cordwood for which the market is very limited and the growth of all species is very slow. This type of land might be called devastated in that there appears little probability of its composition changing except for the worse as time goes on. It hardly seems possible to alter this type by cutting methods, since the blackjack oak is a prolific sprouter and has a tendency, accordingly, to increase its proportion in a stand following cutting operations. Although success is not assured, the only recourse seems to be that of planting such areas to pine. Shortleaf pine appears to be the logical species to use since the region lies within its natural range. Owing to the rather open habit of shortleaf pine, however, it does not seem that this species will ever shade out the oak even if it should succeed in overtopping it. It might be worth while to try other species also, such as white pine and Scotch pine.

MEMORANDUM FOR MR. CLAPP

I will record here my views regarding the "minimum requirements" studies, based upon the very interesting and instructive conferences of last week.

The broad purpose of this series of reports is to put before the forest landowners and general public:

(1) The recommendations of the Forest Service, based upon our experience and investigations to date, as to the methods of protection and silviculture which will secure reasonably complete and valuable timber crops in accordance with the possibilities of the site and type. These should be addressed primarily to the landowner who contemplates the intensive use of his land for timber production.

(2) The measures or steps which we believe essential to prevent denudation of forest lands and to keep them reasonably productive. These should be worked out from the standpoint of the landowner who is disposed to take the first steps in forestry (as with a view to government purchases or exchanges) and should indicate the scope and character of the public regulations necessary to prevent forest lands from lapsing into an unproductive condition. "Public Requirements" as such should not be featured in the reports by title or otherwise; but they should contain reasonable specific recommendations designed to guide State legislation or administrative action whenever the betterment of forest conditions by this means becomes possible.

Each report should aim to accomplish these broad purposes in the most effective manner for its own region. While the basis of the "minimum" measures should be the physical conditions that must be provided to prevent forest land from becoming barren, this principle should not be adhered to so strictly as to prevent the most common sense and effective presentation in view of the situation in each region. In my judgment economic factors and the more progressive opinion or practice of forest landowners in the region will necessarily influence the measures recommended to a greater or less degree. I see no reason why they should not. Let us bear in mind that the purpose of this series of publications is to promote progress in forestry practice and that the most effective way of accomplishing that purpose in each region should guide the nature and form of presentation of the report. In our western districts, for example, probably excepting redwood, I believe that our minimum measures might well set their sights somewhere near the best practice as yet adopted by any of the private landowners.

Similar considerations of effectiveness in dealing with a particular region should also govern the structure of the reports. It is not necessary to make these uniform. Where it is believed desirable to treat the "minimum measures" and the "desirable forestry practice" as distinct sections, that method should be employed. If a regional situation can be better dealt with, however, by combining the two, either building from the bottom up or from the top down, I would not hesitate to prepare the report accordingly.

With the same idea of flexibility in mind, there should be no hesitation to include alternative measures, as between selection cutting and clean cutting, with a brief presentation o the merits, drawbacks, and possibilities of each, or supplemental discussions dealing with secondary forest industries or forms of forest management adapted to particular requirements. Where worth while, for example, we might distinguish between the measures adapted to virgin stands and those adapted to second growth stands. The guiding point again should be how to put the main ideas in the report over most effectively in consideration of the needs and problems of the region concerned.

We should of course frankly recognize ourselves, and probably state specifically in the general introduction to all reports, that no finality is claimed for the measures proposed, and particularly that our intensive forestry practice is bound to develop rapidly and change to some extent as forest research is extended and practical experience gained. The introduction should make clear that the Service is attempting no more than to put in reasonably concrete form the results of the experience and investigative work in the United States to the present time, for the purpose of practical aid in protection and timber growing on private lands.

The approximate cost of the measures proposed under both "minimum" and "desirable" should be indicated as far as practicable. It is unnecessary to discuss the question as to whether certain of these costs or all of them should be regarded as chargeable to the logging operation or as an investment in second growth It is important, however, to point out to what extent the measures proposed:

(1) Are necessary or desirable for the protection of merchantable timber or logging investment, or to reduce the cost of fire fighting, etc.

(2) Reduce logging costs or do not involve real financial sacrifice, as in the case of small timber, defective seed trees, etc.

In general, the reports should contain no positive statements as to the success or the impossibility of commercial reforestation in the region concerned. They should indicate, however, conservatively, what may be expected in future yields if the two general groups of recommendations are followed. Possibly an exception to the foregoing should be made in the case of the Rocky Mountain lodgepole region, the southwestern pine region, and the Appalachian spruce type. Possibly it would be best for the reports to say plainly in those cases that intensive forestry practice does not appear feasible for the private owner for at least a long time to come; and hence that little progress in intensive forest management can be expected, except under public ownership.

In general, the treatment in the report should not be technical and should be aimed at the landowner and the everyday reader — not the professional forester. In the regions containing a large number of forest types or variations, the reports would miss their mark if they attempted a detailed or complete discussion of all of them. At the same time, I believe it essential for their purpose that either the most important forest types or the types most distinctive of the major forest acreage in the region should be treated in a fairly comprehensive way, or, as an alternative, that suggestive and illustrative examples of good forestry practice be included.

I favor the inclusion of a recommendation for management plans covering individual properties as part of the "desirable" forestry practice of the regions which are reasonably ready for this development. This recommendation, however, should supplement rather than replace a sufficient discussion of silvicultural methods to at least make clear certain illustrative forms of practice that the Service recommends. Furthermore, in advocating management plans, I am inclined to think that we should definitely include the regulation of cut on the sustained yield principle as an important feature. This might be presented as a phase of forestry practice not always possible at first but as essential in fully developing the management plan idea. It might also be desirable to suggest the possibility of management plans worked out by public agencies for counties, townships, or other practicable units.

I believe that each report should be published separately with a title including key words common to the whole series, combined with the region to which the report applies. A short introduction, indicating the general purpose of the series in some such way as I have presented it in this memorandum should be published with each regional report. All the reports should be kept as concise as possible with a view to getting them read by the nonprofessional audience to whom they are addressed.

As a minor point, it does not impress me as desirable to carry over minor betterments in fire protection into the desirable forestry practice, such as slight differences in patrol organizations, etc. It seems to me that these should be included under the minimum measures. Important insect and tree diseases should be dealt with very briefly and in broad terms in connection with the general protective features. I do not see that we can do much more than point out the existence of these pests and the necessity of incorporating into the forest protection of the region such measures of eradication or control as may be worked out by entomologists or pathologists and found, by test, to be effective.

I am very much gratified by the way in which this whole project is shaping up, as brought out at the Madison conference. I believe that it will represent a very important and valuable contribution from the Service to the forestry movement.

(Signed) W. B. Greeley,

Forester.